Russia's Defenders

The S-300P, S-350, and S-400 SAM Systems

Operational Russian S-300PM battery

Monograph #1

Author's Comments

The *I&A Monograph* series is designed to provide in-depth coverage of topics of interest, most often system overviews or expansive topics not suited for the *I&A* digizine itself. Whereas *I&A* focuses primarily on current status or the latest information, monographs provide an opportunity for a more comprehensive look at various topics, including historical information.

This first monograph details some of the world's most advanced, capable, and sought-after strategic SAM systems: Russia's S-300P, S-350, and S-400 family.

Forthcoming monographs will detail topics such as Soviet and Russian ABM systems,

Sean O'Connor

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INTRODUCTION

The S-300P family of strategic SAM systems represents one of the most capable collections of air defense assets in the world. The first variants, coded SA-10A GRUMBLE by Western intelligence agencies, heralded in a new level of complexity and capability for the then-Soviet SAM forces.

The increased capability of the SA-10A and subsequent SAM systems earned them the nickname of "double digit" SAM systems by Western military arms, a moniker stemming from their Western identifiers denoting their increased lethality over their predecessors. This lethality made the S-300P series of SAM systems highly sought after commodities on the export market.

Today's S-350 and S-400 bring further advances and increased capabilities to the modular design of the family. With export clearance forthcoming and production of the S-300P series nearing a close, the S-350 and S-400 stands poised to be the next major export successes for Almaz-Antey.

DEVELOPMENT HISTORY

Early Development

The S-300 concept first took shape at the end of 1966. With S-200 firing trials all but complete, the VPK solicited concepts for the next-generation SAM system. This new SAM system was to be capable of engaging multiple targets at all altitudes, be highly mobile, and sufficient for employment by the Troops of Air Defense (PVO), the Soviet Army, and the Soviet Navy.

One of the design bureaus to submit a proposal was MKB Strela, headed by Aleksandr Raspletin. MKB Strela would later go on to become NPO Almaz. Raspletin had been instrumental in the creation of the USSR's primary strategic SAM systems of the day: the S-25, S-75, and S-200. MKB Strela's proposal was the S-300 family of systems.

A second proposal was the S-500U. The VPK rejected the S-500U in favor of the S-300 as it lacked the ability to engage missiles. Given that the new system would serve with the Soviet Army, the capability to engage tactical ballistic missiles was a design requirement.

The VPK classified the S-300 as a medium-range SAM system, designed to replace the various S-75 and S-125 batteries defending critical installations around the USSR. In fact, former S-75 locations currently host many deployed S-300P series batteries. As developed variants appeared, the system would also serve as a replacement for the S-200. This was not, however, a design goal; the PVO classified the S-200 and S-300 as long and medium-range systems respectively.

S-300V Split

There was a great deal of debate concerning the development of a single system to serve the three identified military branches. Each branch had a certain requirement that did not necessarily translate to the others: the PVO required a highly mobile system, the Army required a system capable of repelling the new Pershing tactical ballistic missile, and the Navy required a system capable of dealing with low-altitude cruise missiles. The proposed naval variant would be able to share many components with the PVO variant, as the PVO also required the ability to deal with low-altitude targets.

A decision by Central Committee for Defense Affairs Chairman Dmitry Ustinov ultimately settled the issue. Ustinov ordered the development of two systems: the S-300P, tailored for the PVO's low-altitude requirement, and the S-300V, tailored for the Soviet Army's anti-missile requirement. This decision is why the S-300P family and the S-300V family both share a common designator but represent two different SAM systems. The designers tackling the issue of the Army variant rapidly digressed along their own path, beginning with a switch to treaded chassis for the system components.

Raspletin's Final Inputs

MKB Strela went to work on the S-300P in 1969, assigned to develop the PVO variant of the S-300 in a 27 May decree titled "On Creation of the Standardized S-300 System". The decree assigned the Altair and Antey design bureaus to develop the naval S-300F and army S-300V variants respectively. The chief designer of the S-300P was Boris Bunkin, who had assumed the role after the death of Raspletin.

Raspletin, however, had made two key decisions regarding the new system before his passing. These decisions were to incorporate integrated circuitry in the system components and employ a phased array radar system for missile guidance.

As envisioned, the S-300P SAM system was to have the following characteristics:

- Emplacement and tear down time of no more than 5 minutes
- A command system capable of tracking 100 targets and controlling six subordinate batteries
- The ability to place the six batteries 30-40 kilometers from the command system

The following design bureaus would handle the development of key components for the S-300P:

- Almaz TkSB: 5N63 guidance radar and system components
- Fakel MKB: 5V55 missiles
- Novosibirsk Measuring Instrument NII: 5N64 battle management radar used by the 5N83 command system
- Leningrad KBSM: 5P851 TEL

The S-300PT

The first variant of the S-300P to be completed and available for operational service was the S-300PT. Interestingly, the S-300PT existed not as a designed variant but as a solution to a technical problem.

The operational requirements called for a system capable of rapid deployment and redeployment, with a set up and tear down time of no more than 5 minutes. The Minsk Wheeled Prime Mover Plant would modify the MAZ-543 all-terrain chassis to mount the components of the S-300P system to achieve the mobility requirement.

While component testing was taking place at Sary Shagan, it became clear that the system components would complete testing before the MAZ-543 chassis was ready. Ergo, a solution was derived in the form of the S-300PT.

The S-300PT would mount containerized system components at prepared sites, with the launchers placed on trailers. The system was still technically mobile, but the set up and tear down time did not fall within the prescribed requirement, taking up to 120 minutes depending on the configuration of the battery.

The Fakel Moscow Design Bureau (MKB) developed the 5V55 missiles for the S-300P. MKB head Petr Grushin initially planned to employ a containerized hot launch system. In a hot launch, the missile's motor ignites inside the launch canister, in the same fashion that a hot launched ICBM fires its boost motor inside the missile silo.

When the S-300P and naval S-300F were standardized, it became obvious that a hot launch system would not be satisfactory as this represented a hazard to naval vessels equipped with the system. Grushin's solution was to employ a cold launch system, whereby the missile ejects from the launch canister via compressed gas. When it reached an altitude of 20 meters, the motor would ignite. Thrust-vectoring control vanes would then point the missile towards the direction of the target, enabling the missiles to launch without orienting the launcher in the direction of the target.

An explosive charge blew apart the canister's lid before launch. The containerized launch system enabled the missiles to be stored without maintenance for a period of at least ten years.

Initial components of the S-300PT were completed and delivered to Sary Shagan for testing by 1973. Preliminary missile testing had begun in 1972 while awaiting the delivery of the remaining system components.

The early results of the test program were satisfactory enough for serial production of S-300PT components to begin in 1975. The 5V55, however, developed problems shortly thereafter. One issue related to inadequacies in the production process, whereby missiles damaged in production failed when delivered to Sary Shagan for trials. A second issue required a minor redesign of the missile control surfaces.

Following production approval, S-300PT trials continued at Sary Shagan. During low altitude trials, 5V55 rounds began failing due to control surface failure. Higher thermal loads during extended low altitude flight caused the spray-on thermal coating on the steel control surfaces to fail. Redesigned control surfaces employing fiberglass for thermal protection eliminated the problem, with replacement

control fins produced and retrofitted to missiles awaiting delivery.

Testing of the complete S-300PT system continued for 5 years, ending in 1978. In 1979, the PVO accepted the S-300PT into the inventory to begin operational service.

Ukrainian S-300PT battery components deployed near Kharkiv displaying the characteristic 5P851 TELs (Google Earth)

The S-300PS

Development of the mobile S-300PS began immediately following the 1969 decree. Due to the aforementioned delays with the development of the modified MAZ-543 vehicles used to mount the major system components, testing did not begin at Sary Shagan until 1978, the same year that S-300PT testing completed.

The S-300PS test program lasted for three years, ending in 1981. A requirement to develop support infrastructure for the mobile vehicles delayed service entry until 1983. Russia exported the S-300PS as the S-300PMU.

S-300PS Mobility

The S-300PS has a set-up and tear-down time of 5 minutes, provided that a suitable deployment site is located not requiring the use of mast-mounted radars. Mast-mounted radars can take between 45 and 90 minutes to erect, affecting the deployment and redeployment time of the system.

This 5-minute period was the source of doubt for some senior Soviet officers. Colonel-General Anatoliy Khyupenen, the chair of the commission overseeing the testing of the S-300PS, was one of these individuals. To validate the performance of the system, engineers conducted a test with amusing yet irrefutable results.

S-300P batteries operate as part of a system controlled by a central command post, which operates the target acquisition radar set. Each battery ties in to a specific location in order to facilitate automatic target engagement.

Geodesic tie-in serves to align the engagement radar’s autonomous detection sector with the azimuth and elevation of the target. Without accurate reporting of the battery's position, target deconfliction or track assignment functions may not be as effective. A severe enough inaccuracy can result in a target track assignment outside of the radar’s present field of view, making intercept impossible.

A 1T12 survey vehicle performs automatic geodesic tie-in of a deployed S-300P battery to the surrounding area, a process that takes no more than 5 minutes. It is important to note that such functions are not necessary in tactical SAM batteries, which do not tie in to a specific firing zone and often operate without higher-level target track assignment.

The firing exercise conducted for Colonel-General Khyupenen was to involve the deployment of a battery to a preselected firing location. A pre-selected location allowed for the collection of the maximum amount of telemetry data on the test. This did not sit well with Colonel-General Khyupenen, who viewed the use of a pre-selected launch site as an inaccurate method of gauging the system's deployability.

As it would turn out, an unexpected mishap ended up providing onlookers with a far more accurate demonstration. As the SAM battery was deploying to the launch site, the column of vehicles came to an unscheduled halt, as the engine of one of the MAZ-543 vehicles developed a mechanical problem.

Seizing the opportunity, senior Almaz engineer Vyacheslav Volkov ordered the battery to deploy in place. Geodesic tie-in took place rapidly, and a single missile intercepted the target drone. Deployment of the SAM battery and geodesic tie-in took 5 minutes, validating the mobility of the S-300PS.

Russian S-300PS battery deployed near Kaliningrad (Google Earth)

Upgrading the S-300PT

A modified version of the S-300PT appeared during testing of the mobile S-300PS. The S-300PS had certain increased capabilities, which when applied to the S-300PT created the improved S-300PT-1 variant. Engagement range of the system increased to 75 kilometers and it introduced a new guidance principle, to match the characteristics of the S-300PS.

The S-300PT-1 entered service in 1981, with the first batteries deployed near Severodvinsk. The S-300PT-1A followed the S-300PT-1, introducing further modifications intended to keep the system viable.

Russian S-300PT-1 or S-300PT-1A battery deployed near Severodvinsk (Google Earth)

The S-300PM

While the S-300PS was entering service in 1983, the definitive version of the system outlined in the 1969 requirement, Almaz MKB was beginning work on developing a new, modified version of the system. The S-300PM would incorporate various new components, including a new engagement radar and a new missile. Enhanced performance led to the classification of the S-300PM as a long-range missile system.

The new missile system, developed by the Fakel MKB, was the 48N6. It used more efficient rocket propulsion to double the engagement range of the system without changing the dimensions of the missile to a degree significant enough to necessitate the use of new launch canisters and possibly new launch vehicles.

Testing of the S-300PM concluded in 1988, and in 1989 the first operational batteries were deployed around Moscow. The S-300PM has been exported as the S-300PMU-1.

Russian S-300PM battery deployed near Podolsk south of Moscow (Google Earth)

ATBM Capability

Testing of new capabilities for the S-300P and S-300PM continued even after the S-300PM entered service. The most significant testing occurred in the aftermath of Operation DESERT STORM.

Almaz and Fakel engineers had examined the performance of the American PATRIOT missile system during SCUD missile intercepts and found that the PATRIOT was not nearly as effective as was needed to defend a large populated area. Accuracy was not the issue; PATRIOT missiles consistently found their targets. The problem was one of target destruction.

When the PATRIOT missile warheads detonated, they often simply knocked the SCUD off its flight path without destroying the inbound warhead. When defending an isolated facility, this would be sufficient. However, intercepts attempted by Israeli PATRIOT batteries were of particular interest to the Russian engineers. Often times the inbound warheads still landed in populated areas. To be truly effective in an ATBM capacity, a SAM system would have to destroy the warhead in-flight.

Testing of various S-300P variants at both Sary Shagan and Kapustin Yar proved that the system did have the ability to intercept tactical ballistic missiles at various ranges, depending on the missile system employed and the speed of the incoming target. Fakel MKB engineers, however, developed an even more effective solution in the aftermath of DESERT STORM: a special warhead designed to cause the inbound warhead to detonate in-flight.

The first test firing of the modified warhead occurred in August of 1995 at Kapustin Yar. The missile's warhead successfully caused the warhead of the 8K14 target to detonate in the atmosphere. The missile employed a directional warhead, which is roughly analogous to a shaped charge system insofar as it is able to direct the bulk of the explosive force of the warhead towards the target.

Favorit

A further improved version of the S-300PM was marketed for export as the S-300PMU-2 Favorit. The Favorit missile system incorporated a new class of missiles from the Fakel MKB, along with the weapons used by previous iterations of the S-300P family.

Russian S-300PM batteries received upgrades to Favorit-S standard by early 2012. Favorit-S provides increased capabilities described as analogous to the S-300PMU-2, potentially permitting the employment of the 48N6D. A further improved S-300PMU-3 was briefly mentioned at past defense expositions, but is believed to have been superseded in development by the S-400.

One significant system introduced with the Favorit system is the NK Orientir satellite navigation system. Orientir is positioned atop the driver's cabin of the engagement radar vehicle, and can be found on next-generation TEL prototypes demonstrated for the S-400.

Orientir allows an individual vehicle, be it a radar system or a TEL, to perform

geolocation and navigation tasks to a linear accuracy of 15 meters and an angular accuracy of 6 degrees of arc. The system is available for export, noted atop Chinese S-300PMU-2 engagement radars, and enhances system maneuverability by reducing reliance on dedicated assets such as the site survey vehicle.

The S-400

Development of the S-400 commenced in 1985 as a replacement for the S-200 strategic SAM system. The program had a stated range requirement of 400 kilometers, 100 kilometers greater than the latest S-200D variant. Almaz would develop the system architecture, with Fakel developing the new long-range missile.

In the early 1980's, Almaz had also begun work on the original S-350, a next-generation SAM system designed to be the eventual successor to the S-300P series. During the course of preliminary research and design efforts for both systems, it was determined that both systems could be standardized, using the same components. The long-range missile designed by Fakel would allow the new system to meet the 400-kilometer range requirement. Preliminary design approval occurred in 1988, and the system gained the name Triumf.

The "new" S-400 began trials at Kapustin Yar in 1993. The system likely retained the S-400 designator to highlight the long-range performance. It would also be simpler to integrate shorter-ranged weapons from the S-350 complex into the S-400, rather than redesigning S-350 systems to handle the longer-ranged weapon of the S-400.

Fakel MKB engineers began work on dealing with the issue of a 400 kilometer ranged missile immediately upon the initiation of S-400 development. Boris Bunkin and Petr Grushin analyzed the characteristics of the 48N6 series missiles and realized that there was still potential in the missile for increased range.

Initial S-400 trials employed non-standard components (Almaz-Antey)

The missiles of the S-300P series weapons initially fly a near-ballistic profile towards their target. Increasing the altitude at apogee of the trajectory would result in a corresponding increase in range. In-service weapons had their apogee restricted to 38 kilometers. This was because at a higher altitude the aerodynamic control surfaces would no longer function effectively. Thrust vectoring control used during the boost stage was no longer viable, as the motor had already burnt out prior to reaching apogee.

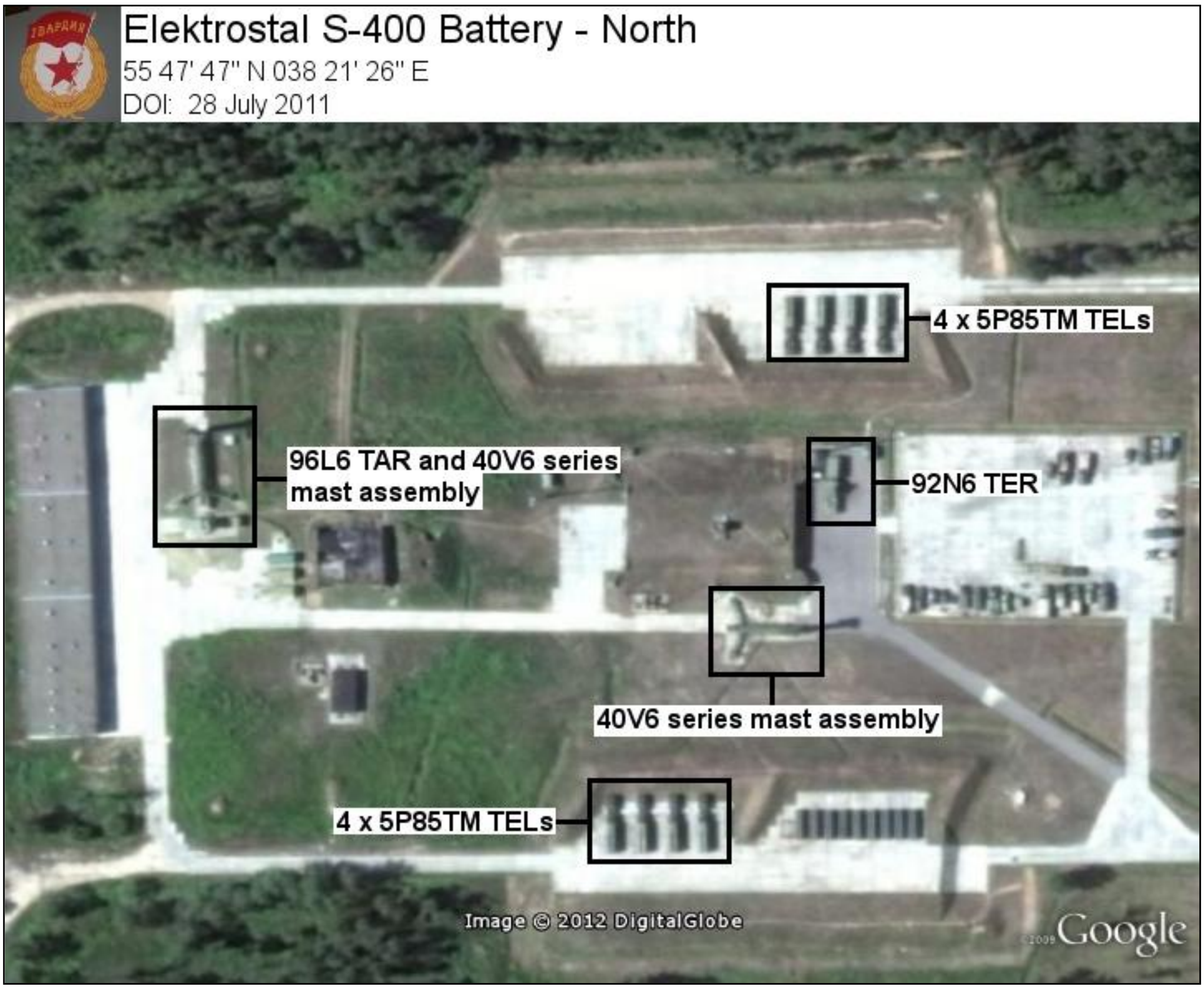
Testing revealed that operating the control surfaces at higher altitudes resulted in instability in the flight path, potentially influencing the accuracy of the weapon. Furthermore, too much instability could result in the missile becoming uncontrollable or the airframe failing. Bunkin and Grushin's solution to increase the range of the missile system was to modify the control surfaces to allow them to lock during the near-ballistic portion of the trajectory. This would eliminate any unwanted movement, with the control surfaces

unlocking upon reaching lower altitude to provide maneuverability during endgame.

Fakel tested the new missile in 1985 and reached an apogee of 70 kilometers. The significant increase in altitude enabled the missile to fly out to a range of 400 kilometers. Upon descending to 20 kilometers, an experimental engagement radar complex recaptured the missile's guidance system and it guided normally, validating the concept of a 400-kilometer missile for the S-400.

After the 400-kilometer test firing, Almaz MKB set about redesigning the experimental engagement radar components to allow a mobile chassis to mount the system. S-400 design approval occurred in 1988. Events surrounding the breakup of the Soviet Union would affect production of system components, so testing of the S-400 did not commence until 1993. By this time, testing of strategic-level SAM systems relocated to Kapustin Yar in southwestern Russia as Sary Shagan now resided in the independent nation of Kazakhstan. System testing initially commenced with the existing 48N6D missile, with testing of the new 48N6DM designed for the S-400 reported in 2004.

The first S-400 regiment entered operational service near the town of Elektrostal in the Moscow region on 6 August 2007 with the delivery of the first operational battery. The regiment received a second battery in 2008. Moscow anticipates a defensive network of 28



S-400 regiments by 2020, with two batteries per regiment. Future S-400 deployments may include the Kola Peninsula and the Kurile Islands.

Engagement radar and TEL of an operational S-400 battery (Almaz-Antey)

As of mid-2013, the S-400 served with at least five regiments. Two regiments defend Moscow, one Kaliningrad, one Novorossiysk, and one Nakhodka. While each regiment expects to operate two batteries, Nakhodka only currently deploys a single battery. A second battery potentially remains stored awaiting deployment; this occurred with the Kaliningrad regiment, with first one and later two deployed batteries noted in imagery. Forthcoming deployments include Novorossiysk, and potentially an additional battery to the Nakhodka regiment.

S-400 components on display (Almaz-Antey)

At some future point, Russia intends to switch various S-400 components from MZKT-series chassis and mount system components solely on BAZ-series chassis. One advantage of this practice is increased load capacity for missile TELs, an important feature when the new 40N6 missile is operational. In addition, a series of common chassis will reduce maintenance and upkeep costs.

The S-350 Returns

In 2013, the S-350 designator reappeared, now referring to the Vityaz SAM system. Almaz-Antey, the air defense corporation formed by the merger of Almaz and Antey in 2002, reports that the current S-350 remains the intended successor for S-300PT and S-300PS batteries.

The reappearance of the S-350 does not imply an overt connection with the original S-350 program. Rather, the current S-350 stems from work done on the joint Russian-Korean KM-SAM, itself a variation on the Almaz MRADS design exhibited in model form at various defense exhibitions since the early 2000s. Almaz-Antey aided in the development of the KM-SAM's PESA. Russian military approval for the S-350 came in 2007, following successful development of the KM-SAM. In this vein, KM-SAM can be viewed as a proof-of-concept for the S-350.

Russia intends to acquire up to 30 Vityaz batteries by 2020, serving to complement the S-400 in much the same manner that the improved S-300PM complemented the earlier S-300P variants. Extant S-300PT and S-300PS batteries will retire by 2015; the S-300PM will serve longer thanks to the Favorit-S upgrade.

SYSTEM COMPONENTS

Modular Design

The S-300P is a modular SAM system. Various different system components are required to make the system operational, and there is a degree of choice involved in which system components to employ. Certain deployment strategies may require the use of independent acquisition radars, for example, and there are numerous different TEL iterations available for the system.

Engagement Radars

The most critical radar in any SAM system is the target engagement radar. The engagement radars used by the S-300P, S-350 and S-400 series SAM systems are large phased array radars. A trailer mounted the initial engagement radar for the S-300PT for transportation, with subsequent models placed on all-terrain vehicles for rapid deployability and enhanced system mobility over rough terrain.

The initial engagement radar employed by the S-300P was the 5N63, produced in two primary versions: the 5N63, a containerized system designed for the S-300PT and the 5N63S, a mobile variant mounted on a MAZ-543M chassis for the S-300PS.

An FR-10 transport trailer carries the 5N63. When deployed, the wheels detach from the FR-10 and the body of the trailer rests on the ground where the radar is to erect. The system's nomenclature refers to the 5N63 radar system and array as container F-1. Container F-2 houses the operator stations for the engagement radar, and container F-3A contains the electronics for controlling up to three TELs, which connect to the F-3A by cables. Container F-2 controls up to four F-3A containers, permitting a maximum of 12 TELs in a battery.

The 5N63S retains the basic containerized architecture of the 5N63. The primary difference is the method of transportation. Containers F-1S and F-2S mount in tandem on the back of a MAZ-543M all-terrain chassis, with container F-3S mounted behind the cabin of one of the TEL vehicles. The MAZ-543M also mounts a radio antenna for communicating with the command post and receiving target track data for the engagement radar.

5N83S engagement radar (Almaz-Antey)

The 5N63S has the following characteristics:

- Target speed: 50 to 1200 meters per second
- Autonomous detection sectors:
  Low altitude: 1 degree elevation by 105 degrees azimuth
  Medium and high altitude: 4 degrees elevation by 12 degrees azimuth

The engagement radar employed by the S-300PM is the 30N6. The 30N6 features an enlarged and redesigned radar array and improved performance over the earlier 5N63 series. As with the 5N63S, the F-1M and F-2M containers mount in tandem on the back of a MAZ-543M chassis. The TEL employs a new radio antenna to communicate with the command post, and improvements to the system architecture alleviated the need for an F-3 container variant for TEL control.

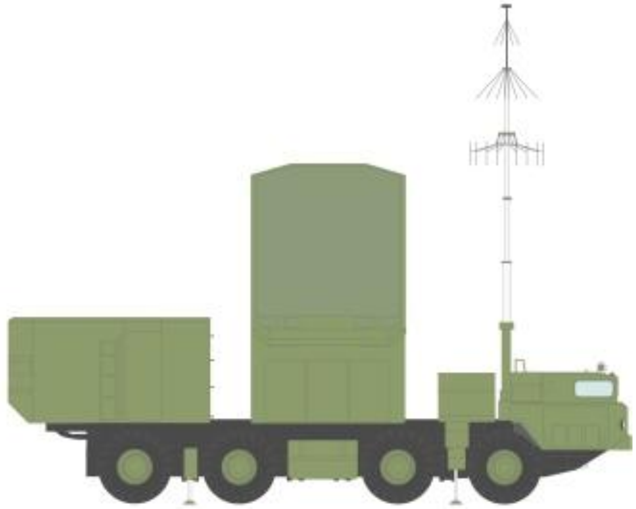
The 30N6 has the following characteristics:

- Target speed: 0 to 2800 meters per second
- Autonomous detection sectors:
  Low altitude: 1 degree elevation by 90 degrees azimuth
  Medium altitude: 5 degrees elevation by 64 degrees azimuth
  High altitude: 14 degrees elevation by 64 degrees azimuth
  Ballistic targets: 10 degrees elevation by 32 degrees azimuth
  Scanned Elevation: -3 to +85 degrees

Two variants of the 30N6 are available for export, the 30N6E1 and 30N6E2. The 30N6E2 is associated with the Favorit system and shares the same basic characteristics as the 30N6E1, differing primarily in the engagement range offered by the Favorit's longer-range missiles.

30N6 engagement radar (Almaz-Antey)

The 30N6E radar employed by the export S-300PMU is a modified 5N63S. The 30N6E incorporates features of the 30N6 but retains the radar array of the 5N63S.



Deployed 30N6E engagement radar (Carlo Kopp)

All of the engagement radars used by the S-300PS and S-300PM share the following characteristics:

- Simultaneous engagements: 6
- Missiles guided per target: 2
- Measurement accuracy:
  Range: 5 meters
  Speed: 1 meter per second
  Angular coordinate difference: 1 arc minute
- Response time to targeting data from command post: 9 to 11 seconds (airborne target), 5 to 6 seconds (ballistic target)
- Emplacement time: 5 minutes
- Crew: 6

The engagement radar used by the S-400 is the 92N6. The 92N6 features a further revised radar array when compared to the 30N6. The all-terrain chassis is new as well. In place of a MAZ-543M chassis, the 92N6 and its associated control container mount in tandem on the back of an MZKT-7930 chassis.

Publicly released characteristics of the 92N6 are as follows:

- Simultaneous engagements: 6
- Missiles guided per target: 2

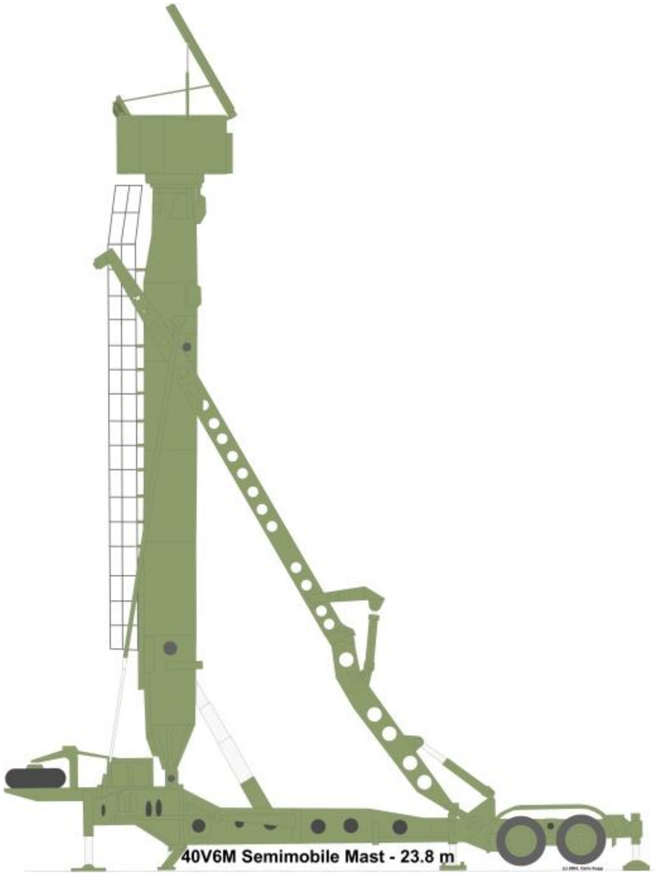
* Target speed: 0 to 4800 meters per second

92N6 engagement radar (Almaz-Antey)

The engagement radars for the S-300P and S-400 series are space-fed PESA systems. The S-350 engagement radar, the 50N6, incorporates a similar space-fed PESA design, albeit with a wholly new array face.

All engagement radars can employ either a 23.8-meter 40V6M mast assembly or a 38.8-meter 40V6MD mast assembly to increase low altitude capability in areas with uneven terrain or obstructions. A variant created for the 92N6 engagement radar is the 40V6MR. A MAZ-537 is used to tow the 40V6M for transport, with the 19 meter extension used by the 40V6MD being mounted on a MAZ-938 trailer towed by a KrAZ-250.

The mast assembly exists to enhance the ability of the system to detect and prosecute low altitude targets. The masts themselves were at one juncture a point of contention with the then-CINC PVO, General I. M. Tret'yak. General Tret'yak was concerned that transporting the large, heavy mast assemblies would damage bridges all around the Moscow area. As it turned out, the system designers had selected the mast assemblies for a reason.



Mast-mounted 5N63S engagement radar (Carlo Kopp)

Forests surrounding Moscow would need clearing in order to guarantee low altitude performance at a height of 50 meters. The choice was either to develop transportable masts or erect fixed towers at the launch sites, as forest clearing represented a time consuming and expensive proposition. Fixed towers did not represent a viable option, as they would effectively negate the mobility of the system by forcing it to remain tied to a static location. The only drawback to using the 40V6 series towers is the emplacement time. The 40V6M takes 60 minutes, with the 40V6MD requiring 120 minutes.

Mast-mounted 30N6 radar (Almaz-Antey)

Acquisition Radars

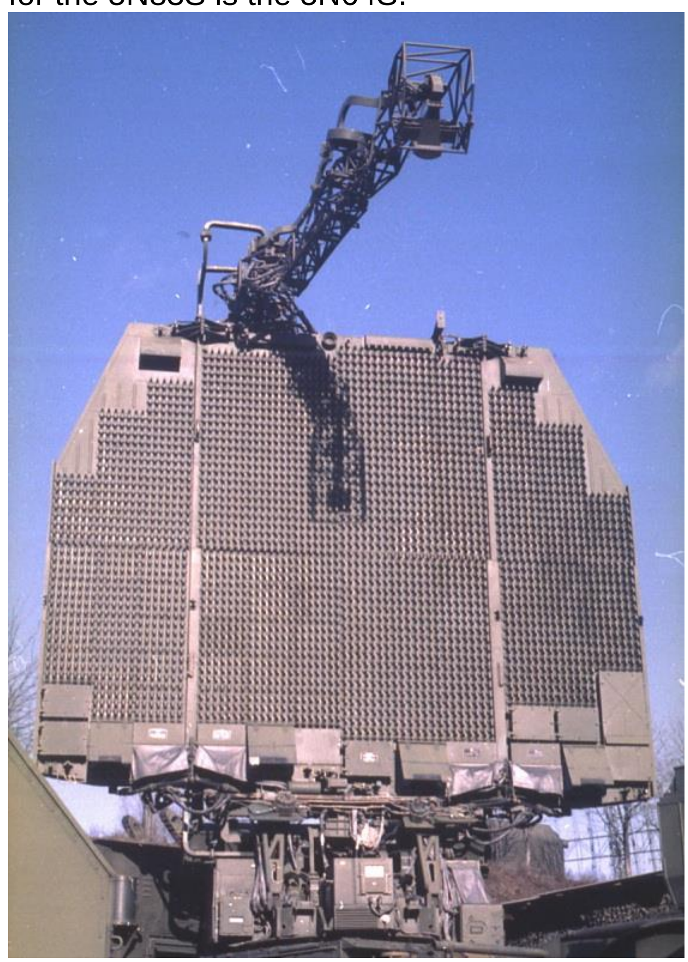
S-300P and S-400 variants employ various different target acquisition radars. These range from dedicated battle management radars to specialized radars for detecting low-altitude targets.

The battle management complex of the S-300P and S-400 represents the central command post for each SAM complex. In all versions, the complex can control up to six separate batteries.

The central command post controls the primary acquisition radar and assigns target tracks to individual batteries, a process that can occur automatically. The central command post also contains a 53L6 cabin for interfacing with the Baikal automated control system. All of the associated engagement radars possess the ability to acquire targets in their assigned sectors independently, but the primary source of target track data remains the associated battle management complexes.

The battle management complex for the S-300P series is the 5N83. It consists of a 5K56 command post designated container F-9. Also present are containers F-6, the acquisition radar, F-7, and F-8, the F-7 and F-8 containing electronics related to the radar system. Two variants of the 5N83 exist: the 5N83 in containerized form for the S-300PT and the 5N83S in mobile form for the S-300PS. In the 5N83S the 5K56 command post mounts on a MAZ-543M chassis. Containers F-6, F-7, and F-8 mount on a 9988 trailer towed by a MAZ-7410.

The acquisition radar employed by the 5N83 complex is the 5N64. The mobile variant for the 5N83S is the 5N64S.



5N83S antenna detail (Almaz-Antey)

The battle management complex for the S-300PM is the 83M6. This complex consists of a 54K6 command post, designated container D-9, mounted on a MAZ-543M chassis, and an acquisition radar system. The acquisition radar system consists of containers F-6M, the acquisition radar, and F-8M, an electronic equipment station, and mounts on a trailer towed by a MAZ-7410.

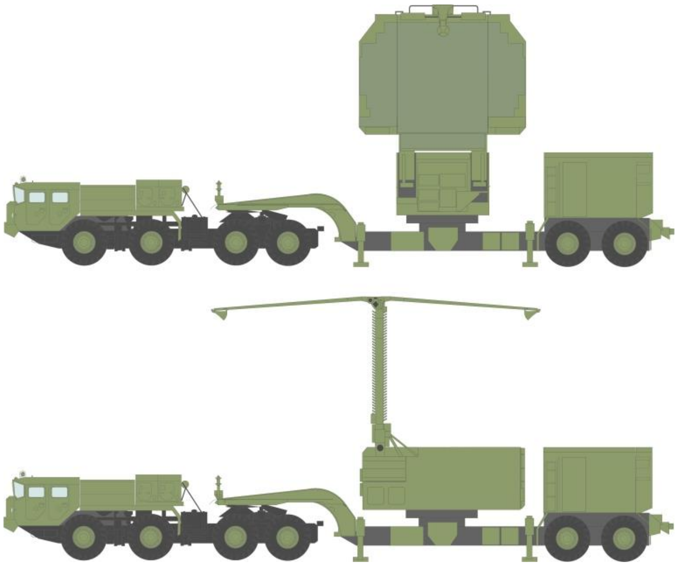
The acquisition radar employed by the 83M6 complex is the 64N6, a modification of the earlier 5N64 series radar systems.

64N6 battle management radar deployed (Almaz-Antey)

The 64N6 radar system has the following characteristics:

- Targets detected in one scan: 300
- Targets tracked: 100
- Targets assigned: 36 (6 to each of 6 batteries)
- Maximum detection range:
  Airborne target: 300 kilometers
  Ballistic target: 127 kilometers with an RCS of 0.4 square meters
- Scanned area:
  Azimuth: 360 degrees or 180 degrees
  Elevation: 0 to 14 degrees or 0 to 28 degrees
- Ballistic target detection sector:
  Azimuth: up to 60 degrees
  Elevation: 0 to 55 degrees or 20 to 75 degrees
- Target speed: 2800 meters per second
- Measurement accuracy:
  Range: 150 meters
  Azimuth: 0.5 degrees
  Elevation: 0.5 degrees
- Revolutions per minute: 5
- Emplacement time: 5 minutes
- Crew: 6

The 83M6 export variant for the S-300PMU and S-300PMU-1 is the 83M6E, with the 54K6E command post and the 64N6E radar system. The initial export-standard acquisition radar was the 5D6E. Export of the 83M6E system with the S-300PMU, based on the S-300PS, implies that an 83M6 complex can control both S-300PM and S-300PS batteries. The system exported with the S-300PMU-2 is the 83M6E2, with the 54K6E2 command post and the 64N6E2 acquisition radar. The 64N6E2 differs in performance with the 64N6E only in the area of the ballistic target detection sector. In the 64N6E2 radar, the elevation value is from 0 to 75 degrees.



Deployed 64N6 battle management radar (Carlo Kopp)

The battle management complex for the S-400 is the 30K6. This complex consists of a 55K6 command post mounted on an Ural-532301 chassis and a 91N6 acquisition radar mounted in a similar fashion to the 64N6 or 5N64S. The 30K6 complex can interface with 83M6 complexes to allow control of S-300PM batteries. The S-350 employs the 50K6 command post mounted on a BAZ-6909 chassis.

91N6 battle management radar (Almaz-Antey)

The 91N6 has significantly increased capability over the previous acquisition radar systems employed with the S-300P variants with major capabilities including the following:

- Targets tracked: 300
- Maximum detection range: 600 kilometers

The 5N64, 64N6, and 91N6 are dual-sided radar systems utilizing space-fed PESAs. Feedhorn assemblies transmit radar signals to the array faces. In making one 360 degree revolution, the radar acquires three fixes of a target to generate initial track data. Following this, track data updates twice per revolution.

The acquisition radars utilized by the S-300P and S-400 are very capable systems, but an increase in low-altitude target tracking was desired for the S-300P. The low altitude radar system developed for the S-300PT was the 5N66. The radar array is designated container F-5. The battery's F-2 container controls the radar array. The 5N66 and 76N6 radars deploy atop various iterations of the 40V6 mast assembly.

The 5N66 radar determines the range, speed, and azimuth of low altitude targets with the following accuracy levels:

- Range: 250 meters
- Speed: 2.4 meters per second
- Azimuth: 20 minutes

The improved 5N66M radar system appeared for the S-300PS. This consisted of a container F-5M for the radar system itself, and container F-52M housing electronic equipment. In this variant, the radar system is either controlled from container F-52M, or from the battery's F-2S container.

A further improved variant developed for the S-300PM is the 76N6. This variant consists of the F-5MU and F-52MU containers. An export-standard model is the 76N6E, for use with S-300PMU and S-300PMU-1 systems.

Mast-mounted 5N66M radar (Almaz-Antey)

The 5N66M and 76N6 have the following characteristics:

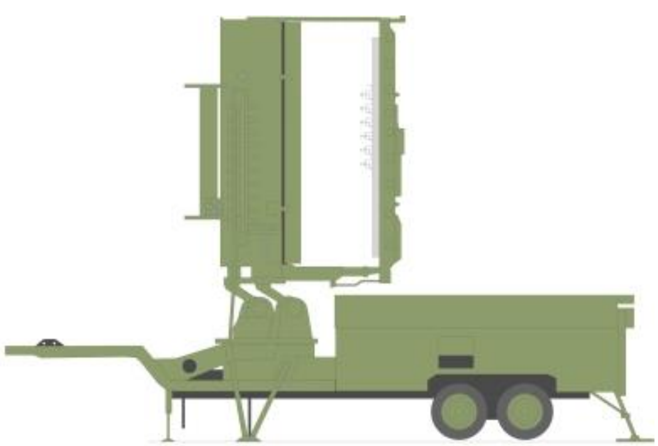
- Altitude threshold: 3 kilometers
- Maximum detection range:
  Low altitude: limited by radar horizon
  500 meters: 90 kilometers

1000 meters: 120 kilometers
- Revolutions per minute: 20

The 2D 5N66 and 76N6 radars utilize separate transmit and receive antennae, separated vertically by a horizontal structure containing feedhorn and waveguide subassemblies. The upper reflector serves as the receive antenna, with the horizontal structure serving to block the reception of clutter signals reflected from the ground.

A self-sufficient target acquisition capability can also be afforded to individual batteries by employing either the 36D6 or 96L6 radar system. Employing one of these radar systems allows individual batteries to operate without support from a battle management complex, or allows an export client with a small number of batteries to perform long-range target acquisition functions without the additional expense of the battle management system. Alternatively, these radar systems, in conjunction with deployed low altitude radar systems, can refine target track data and pass this information along to the engagement radar.

The first battery-level acquisition radar deployed with the S-300P family was the 36D6. The 3D 36D6 utilizes a linear transmitter mounted to a parabolic reflector, a similar arrangement found in the smaller 9S18 acquisition radar for the initial variants of the 9K37 SAM system.



Deployed 36D6 EW radar (Carlo Kopp)

The 36D6 radar system is self-contained on a trailer unit, towed by a KrAZ-255 or KrAZ-260 tractor. A second trailer contains electronic components and the operator control cabin. Variants of the 36D6 associated with the S-300P family include the 19Zh6 and ST-68U.

The 36D6 can deploy atop the 40V6M and 40V6MD mast assemblies. Prior to 1994, Russia and the USSR exported the ST-68U as the acquisition radar component of the 83M6E rather than the more advanced 5D6E or 64N6E.

Characteristics of the 36D6 are as follows:

- Altitude threshold: 20 kilometers
- Maximum detection range: 5 to 160 kilometers
- Emplacement time:
  Power on time: 3 minutes
  Emplacement time: 60 minutes
- Crew: 3

A next-generation acquisition radar, first advertised with the S-300PMU-2, is the 96L6. This 3D planar array radar is mounted on a MAZ-7930 chassis, and can be alternatively be deployed atop 40V6 series mast assemblies.

Deployed 96L6 EW radar (Carlo Kopp)

The 96L6 can operate with all S-300P variants and is associated with the S-400. It is intended to replace 5N66 series and 36D6 series radars with one system capable of

handling both very low altitude target acquisition and long-range EW support.

Characteristics of the 96L6 are as follows:

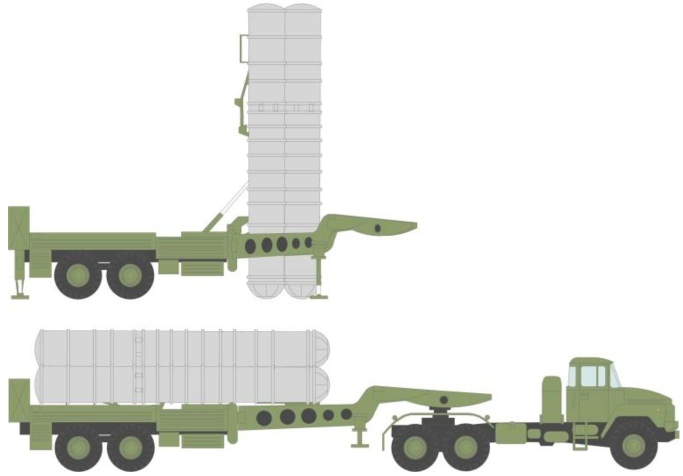
- Maximum detection range: 300 kilometers
- Scanned area:
  Azimuth: 360 degrees
  Elevation: -30 to 60 degrees
- Target speed: 30 to 2800 meters per second
- Revolutions per minute: 15
- Emplacement time: 5 minutes
- Crew: 3

Operational 96L6 EW radar (Almaz-Antey)

Launch Vehicles

The S-300P, S-350 and S-400 systems employ various different TELs. All TELs contain an erecting arm for an assembly mounting the missile canisters. S-300P and S-400 TELs typically employ four missiles.

The TEL employed by the S-300PT is the 5P851. This TEL has an unusual configuration. A KrAZ-258 tractor tows the TEL to a launch position. The TEL then decouples from the tractor for emplacement. The missile canisters erect forward towards the front of the trailer, which splits apart to form two stabilizing arms. This unusual configuration resulted in an emplacement time of 30 minutes. An improved TEL, the 5P851A introduced for the S-300PT-1 system, had improved maintenance characteristics.



Provisional drawing of the 5P851 (Carlo Kopp)

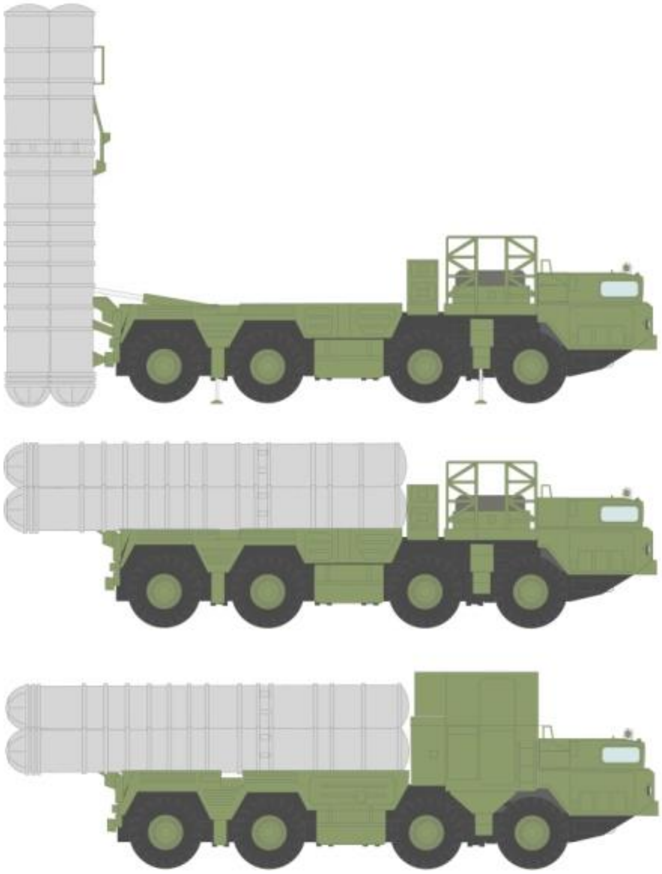
The 5P85SD TEL complex employed by the S-300PS consists of two different TELs mounted on MAZ-543M chassis. The 5P85S TEL contains the system's F-3S cabin used for interfacing with the engagement radar complex and processing launch commands. The 5P85D TEL lacks the F-3S cabin.

Each F-2S cabin connects by cable to up to four 5P85S TELs. Each 5P85S TEL then connects by cable to one or two 5P85D TELs, giving an S-300PS battery the ability to control up to 12 TELs. A radio antenna can also communicate with the F-2S container of the engagement radar complex.

Early-model 5P85D TEL (Almaz-Antey)

Early and late model 5P85SD complexes differ primarily in the size and shape of the equipment areas aft of the operator's cabin. Early 5P85D TELs, for

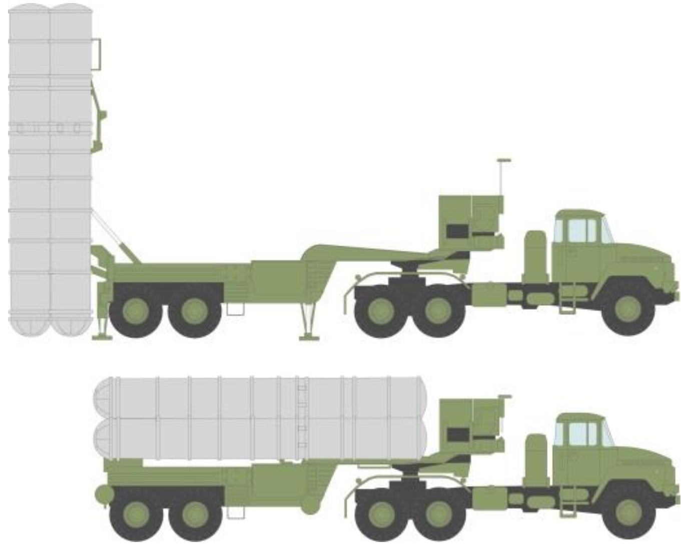
example, feature smaller equipment housings. Late model 5P85D TELs feature a larger fairing. Export TELs for the S-300PMU are the 5P85SU and 5P85DU.



5P85DU (upper, deployed and stowed) and 5P85SU (lower) TELs (Carlo Kopp)

The S-300PM reverted to a towed TEL, the 5P85T. The 5P85T retains the 5 minute setup time of the MAZ-543M based 5P85SD complex thanks to a different configuration when compared to the 5P851.

The 5P85T does not need to be decoupled prior to emplacement, as the missile canisters erect to the rear of the trailer. A KrAZ-260 tows the 5P85T. 5P85T communication with the 30N6 engagement radar's F-2M cabin occurs via radio signal using a disc-shaped antenna or by cable connection.



5P85T TEL in both deployed and transit configurations (Carlo Kopp)

Decoupled 5P85T TELs at an operational S-300PM battery (Almaz-Antey)

A modified 5P85S TEL variant, the 5P85SM, is an option for both the S-300PM and S-400. The 5P85SM differs visually from earlier 5P85S variants by the use of a disc antenna for communicating with the F-2M container, and by the situating of the missile canisters in the stowed position. In earlier 5P85S and 5P85D TELs, the missile canisters extend forward to the second set of wheels. In the 5P85SM, the missile canisters extend forward past the rear of the second set of wheels.

As with the 5P85T and 5P85D, the F-3 container is absent on the 5P85SM. The 5P85SM can also employ cable connections for communicating with the F-2M container. Export variants of the 5P85SM are the 5P85SE and the 5P85SE2, for the S-300PMU-1 and S-300PMU-2 respectively.

The baseline TEL employed by the S-400 is the 5P85TM. This is a modified 5P85T towed by a BAZ-64022, and employs a disc antenna for communicating with the 92N6 engagement radar. Cable connections may also be used.


5P85TM TEL (Almaz-Antey)

Although it does not appear to serve in large numbers with Russian S-300P batteries, the 5P85SM has appeared in recent military parades in Moscow and at Kapustin Yar in association with S-400 trials. Additionally, the Nakhodka-based S-400 battery employs the 5P85SM TEL. The 5P85SM may yet be rotated into operational S-300PM batteries as funding permits, particularly if S-300PM batteries displaced around Moscow by S-400 batteries are transferred elsewhere to replace S-300PT or S-300PS systems prior to S-350 deployment.

The mobile 5P90S TEL, based on the BAZ-6909 chassis, appeared in 2011, associated with the S-400. A towed variant is designated 5P90TM. The BAZ-6909 also hosts the 50P6 TEL associated with the S-350. The Vityaz TEL employs individual launch tubes, with twelve missiles per TEL in a stacked layout featuring two rows of six missiles each. In 2012, a new mobile TEL variant appeared, based on the MZKT-7930 chassis and therefore likely associated with the S-400, designated 51P6A. Either new TEL represents a possible upgrade for displaced S-300PM batteries. S-300PM batteries re-equipped with a new mobile TEL are logical replacements for extant S-300PS batteries awaiting S-350 conversion should the increased mobility remain a requirement. The new TELs may also represent export-targeted alternatives to the 5P85TE2, the current towed TEL produced for S-300PMU-2 clients based on the S-400's 5P85TM.

Summary of S-300P containerized architecture

Container	Notes
F-1	Engagement radar
F-2	Battery command post
F-3	TEL automated control
F-4	Unknown
F-5	5N66/76N6 control post
F-6	Battle management radar
F-7	Electronics
F-8	Electronics
F-9	Central command post

Missiles

The Fakel MKB developed all of the missiles employed by the S-300P and S-400 variants. Engagement range of the S-300P family has increased with each variant and now stands at 200 kilometers when employing the latest 48N6D missiles.

The original missile family developed for the S-300P was Fakel's 5V55 series. The 5V55 missile is available in four different variants. The initial 5V55K was a command-guided missile with a maximum range of 47 kilometers. The 5V55KD appeared with the S-300PT-1, with range increased to 75 kilometers to match that of the 5V55R introduced with the S-300PS. The S-300PT-1 was also capable of employing the 5V55R missile. Likewise, the S-300PS is compatible with the 5V55K and 5V55KD missiles as well. The fourth variant was the 5V55RD with increased range employed by the S-300PS, and exported as the 5V55RUD for the S-300PMU. An inert training round was designated 5V55U.

Characteristics of the 5V55 series weapons are as follows:

5V55K
- Mass: 1480 kilograms
- Warhead: 130 kilogram HE fragmentation
- Engagement range: 5 to 47 kilometers
- Engagement altitude: 25 to 25,000 meters
- Target speed: 1200 meters per second

5V55KD
- Mass: 1660 kilograms
- Warhead: 130 kilogram HE fragmentation
- Engagement range: 5 to 75 kilometers
- Engagement altitude: 25 to 25,000 meters
- Target speed: 1200 meters per second

5V55R
- Mass: 1660 kilograms
- Warhead: 130 kilogram HE fragmentation
- Engagement range:
  Aerial target: 5 to 75 kilometers
  Ballistic target: 5 to 35 kilometers
- Engagement altitude: 25 to 25,000 meters
- Target speed: 1200 meters per second

5V55RD
- Mass: 1660 kilograms
- Warhead: 130 kilogram HE fragmentation
- Engagement range:
  Aerial target: 5 to 90 kilometers
  Ballistic target: 5 to 35 kilometers
- Engagement altitude: 25 to 25,000 meters
- Target speed: 1200 meters per second

The Fakel MKB developed a new missile, the 48N6, for use with the S-300PM system. The 48N6 has double the range of the 5V55R thanks to a new rocket motor. Fakel developed a further improved variant, the 48N6D, for the S-300PMU-2 Favorit. The S-400 employs the latest 48N6 variant, the 48N6DM. Export designators of the 48N6 missiles are 48N6E, 48N6E2, and 48N6E3. The 48N6D and 48N6DM incorporate Fakel's directional warhead for enhanced ATBM capability. The S-300PM can also employ the earlier 5V55 series missiles.

48N6 during ejection (Almaz-Antey)

48N6 following motor ignition (Almaz-Antey)

Characteristics of the 48N6 series weapons are as follows:

48N6

- Mass: 1800 kilograms
- Warhead: 143 kilogram HE fragmentation
- Engagement range:
  Aerial target: 5 to 150 kilometers
  Ballistic target: 5 to 40 kilometers
- Engagement altitude: 10 to 27,000 meters
- Target speed: 2800 meters per second

48N6D

- Mass: 1835 kilograms
- Warhead: 180 kilogram directional
- Engagement range:
  Aerial target: 3 to 200 kilometers
  Ballistic target: 5 to 40 kilometers
- Engagement altitude: 10 to 27,000 meters
- Target speed: 2800 meters per second

Night launch of a 48N6 series missile by an S-400 battery (Almaz-Antey)

48N6DM

- Mass: 1835 kilograms
- Warhead: 180 kilogram directional
- Engagement range:
  Aerial target: 3 to 240 kilometers
  Ballistic target: 5 to 60 kilometers
- Engagement altitude: 10 to 27,000 meters
- Target speed: 4800 meters per second

The Fakel MKB is developing a new missile family for the Favorit, S-400 and Vityaz systems. The 9M96 missiles are highly accurate thanks to the inclusion of advanced gas-dynamic thrust vectoring control systems, which is used in terminal homing to provide a hit-to-kill capability enhanced by the inclusion of an HE warhead.

The 9M96 missiles are compact weapons. A specially designed canister carries four missiles, displacing one of the 48N6 canisters on an associated Favorit or S-400 TEL. This enables each TEL to carry up to 16 9M96 series weapons, or a mixture of 9M96 and 48N6 weapons.

The two variants of the 9M96 are the 9M96 and the longer-ranged 9M96D with an extended motor section. Fakel exports these weapons as the 9M96E and 9M96E2. An inert training round is available as the 9M96R.

Characteristics of the 9M96 series weapons are as follows:

9M96

- Mass: 333 kilograms
- Warhead: 24 kilogram HE fragmentation
- Engagement range: 1 to 40 kilometers
- Engagement altitude: 5 to 25,000 meters

9M96D

- Mass: 420 kilograms
- Warhead: 24 kilogram HE fragmentation
- Engagement range: 1 to 120 kilometers
- Engagement altitude: 5 to 25,000 meters

The long-range weapon designed to give the S-400 its 400-kilometer engagement range is reportedly designated 40N6. As mentioned previously, the 48N6 has proved capable of operating effectively at this range, so 40N6 may in fact be a cover designation for an appropriately modified 400-kilometer ranged 48N6 series weapon destined for the S-400. Ergo, despite rumors persisting of the continued development of what is referred to as the 40N6, it may well be that the S-400 is already capable of engaging targets at maximum range using the existing 48N6DM.

Some sources claim that a 400-kilometer range missile has been in service with air defense units around Moscow since 2001, supporting this line of reasoning. Were this to be the case, the 400 kilometer missile would almost certainly have to be a variant of the 48N6, as the only air defense units capable

of operating such a system around Moscow would have been the various S-300PM batteries. This would also likely imply that off-board targeting of the missile for extreme-range engagements is possible, perhaps using the 64N6 battle management radar, as a 400-kilometer intercept outdistances the range capability of the 30N6. Endgame intercept without the standard SAGG guidance mode provided by the engagement radar would likely be performed using active radar homing were this to be the case.

Active radar homing is another feature commonly attributed to the 40N6 missile. With active radar homing, missiles could theoretically launch using off-board targeting data, allowing them to engage targets outside the range of the engagement radar as SAGG guidance commands would not be required. It may even be possible that new-build 48N6 series weapons came with Bunkin and Grushin's locking control surfaces, allowing them to conduct intercepts at extreme range provided a suitably modified engagement radar was available.

The 40N6 reportedly passed various trials programs between 2010 and 2012, with service entry scheduled for 2013. Until Russia releases more information regarding the 400-kilometer missile system employed by the S-400, the missile providing this capability will remain something of an enigma.

As with most Soviet-era strategic SAM systems, missiles developed for the S-300P appeared as variants armed with nuclear warheads. These weapons were fitted with command-detonated variable-yield warheads of 0.1 to 5 kilotons. Target altitude dictated the warhead yield, with higher altitude allowing the selection of larger yields.

The nuclear missiles for the S-300P series were the 5V55V, employed by the S-300PT, and the 5V55S, employed by the S-300PS. A nuclear variant of the 48N6 was trialed as the 6Zh48. Although the USSR produced roughly 600 warheads for nuclear-armed 5V55 series weapons, no evidence exists that the missiles entered operational service, and the warheads were no longer in the active inventory by the year 2000.

Missiles employed by the S-300P variants employ one of three different guidance systems: command, seeker aided ground guidance (SAGG), and active radar. The 5V55K and 5V55KD are standard command guided missiles, relying on targeting data from the engagement radar complexes. The 5V55R, 5V55RD and all variants of the 48N6 series employ SAGG. Some sources allude to passive radar homing 5V55VM and 5V55PM missiles, but their existence is unconfirmed.

SAGG is a form of guidance similar to the track via missile (TVM) guidance mode employed by the American PATRIOT SAM system. In both SAGG and TVM, the missiles are fitted with semi-active homing heads. The difference lies in how the guidance system interprets seeker data to generate steering commands.

Missiles launch towards their targets relying on inertial guidance based on target position data provided by the engagement radar complex prior to launch. The missile receives midcourse updates via a datalink with the engagement radar complex. Upon reaching a predetermined range, the engagement radar illuminates the target. The semi-active seeker and the engagement radar both receive reflections from the target and generate independent sets of position data. The seeker's position data downlinks to the engagement radar complex, which can also accept updated data from offboard sources such as the 5N66 or 64N6 radar systems. The engagement radar complex then compares all available sets of data to determine the most accurate target position, and guidance commands are then uplinked to the missile. Comparing different sets of data from different perspectives allows the missile system to be extremely accurate, even at very long ranges.

The 9M96 missile systems employ basic active radar homing, relying on inertial guidance and midcourse updates from the

engagement radar complex to get them within seeker range of their targets.

Support Vehicles

Various support systems and vehicles are available for operating and servicing S-300P batteries.

22T6-2 loader reloading an S-400 TEL (Almaz-Antey)

Each S-300P battery will normally possess the following equipment, although different systems will employ different derivatives:

- 5T99 missile loading vehicle on KrAZ-255 chassis, or 5T99M missile loading vehicle on KrAZ-260 chassis (introduced in the 1980s)
- 5I57 diesel generators and 5I58 or 63T6A power converters for operating electrical systems transported on MAZ-5224V trailers
- 1T12 site survey vehicle
- Command staff vehicle on GAZ-66 vehicle
- 5T58 trailer transports missile reload bundles

An alert duty support module services field-deployed batteries. This consists of a guard post, crew quarters, and a mess hall mounted individually on MAZ-543M chassis supported by a power unit mounted on a MAZ-543A.

S-300P battle management complexes will possess the following support equipment:

- 1T12 site survey vehicle
- Command staff vehicle on GAZ-66 vehicle
- 2 5I57 diesel generators and 3 63T6A power converters for operating electrical systems

Summary of S-300P/350/400 system components

Component	System	Notes
Radars		
5N64	S-300PT	EW
5N64S	S-300PS	EW
5D6E	S-300PMU	EW
64N6	S-300PM	EW
64N6E	S-300PMU/-1	EW
64N6E2	S-300PMU-2	EW
91N6	S-400	EW
96L6/E	Various	EW
36D6	Various	EW
19Zh6	Various	EW
ST-68U	Various	EW
5N66	S-300PT	EW
5N66M	S-300PS	EW
76N6	S-300PM	EW
76N6E	S-300PMU/-1	EW
5N63	S-300PT	Engagement
5N63S	S-300PS	Engagement
30N6	S-300PM	Engagement
30N6E	S-300PMU	Engagement
30N6E1	S-300PMU-1	Engagement
30N6E2	S-300PMU-2	Engagement
50N6	S-350	Engagement
92N6	S-400	Engagement
TELs		
5P851	S-300PT	Towed
5P851A	S-300PT-1/1A	Towed
5P85S	S-300PS	SP Master
5P85D	S-300PS	SP Slave
5P85SU	S-300PMU	SP Master
5P85DU	S-300PMU	SP Slave
5P85SM	S-300PM	SP Standalone
5P85SE	S-300PMU-1	SP Standalone
5P85SE2	S-300PMU-2	SP Standalone
5P85T	S-300PM	Towed
5P85TE	S-300PMU-1/-2	Towed
5P85TM	S-400	Towed
5P85TE2	S-300PMU-2	Towed
50P6	S-350	SP Standalone
5P90S	S-400	SP Standalone
5P90TM	S-400	Towed
51P6A	S-400	SP Standalone
Tractors		
BAZ-64022	S-400	5P85TM/TE2
KrAZ-250	Various	MAZ-938
KrAZ-258	S-300PT/-1/-1A	5P851/A
KrAZ-260	S-300PM/PMU-1	5T58/5P85T/TE
MAZ-537	Various	40V6/M/MD
MAZ-7410	Various	9988
Trailers		
5T58	Various	53L6, reloads
5T58-2	S-400	Reloads
9988	Various	BM Complex

FR-10	S-300PT/PT-1/PT-1A	5N63
MAZ-938	Various	40V6MD
MAZ-5224V	Various	5I57/5I58/63T6A
Battle Management Complex		
5N83	S-300PT	Complex
5N83S	S-300PS	Complex
83M6	S-300PM	Complex
83M6E	S-300PMU/-1	Complex
83M6E2	S-300PMU-2	Complex
30K6	S-400	Complex
5K56	S-300PT	Command post
5K56	S-300PS	Command post
54K6	S-300PM	Command post
54K6E	S-300PMU/-1	Command post
54K6E2	S-300PMU-2	Command post
50K6	S-350	Command post
55K6	S-400	Command post
Support Components		
1T12	Various	Site Survey
1T12-2M-2	S-300PMU-1/-2	Site Survey
5I57	Various	Diesel generator
5I58	Various	Power converter
5T58	Various	Transporter
5T58E	S-300PMU-1	Transporter
5T58E2	S-300PMU-2	Transporter
5T99	Various	Loader
5T99M	Various	Loader
22T6	Various	Loader
22T6E	S-300PMU-1	Loader
22T6-2	S-400	Loader
22T6E2	S-300PMU-2	Loader
40V6	Various	Mast assembly
40V6M	Various	Mast assembly
40V6MD	Various	Mast assembly
40V6MR	S-400	Mast assembly
53L6	Various	Baikal interface
63T6A	Various	Power converter
82Kh6	Various	Transformer
83Kh6	Various	Transformer
FL-95	Various	Antenna mast
FL-95M	Various	Antenna mast
FL-95MA	Various	Antenna mast
KS-4561	Various	Crane
KT-80	Various	Crane
MTO-4S	Various	Maintenance

SYSTEM OPERATION AND RUSSIAN USE

Operational Employment

The S-300P and S-400 SAM deploy as complexes responsible for specific sectors. Each complex consists first of a battle management systems with the associated 5N64, 64N6, or 91N6 radar system. The battle management system can manage up to six individual batteries, placed at distances of up to 100 kilometers from the battle management complex.

Each individual battery possesses up to 12 TELs, related support equipment, and the engagement radar. Batteries identify as individual complexes within the system hierarchy, and when exported are sold as complete units assembled to customer specification along with separate corresponding battle management complexes if required. Furthermore, battery-level EW radars such as the 76N6 are correctly described as being subordinate to individual battery complexes, in the same fashion that the 64N6 acquisition radar is subordinate to an 83M6 complex.

S-300P/400 battery designations

System	Battery
S-300PT	5Zh15
S-300PS	5Zh15S
S-300PM	90Zh6
S-300PMU	90Zh6E
S-300PMU-1	90Zh6E1
S-300PMU-2	90Zh6E2
S-400	98Zh6

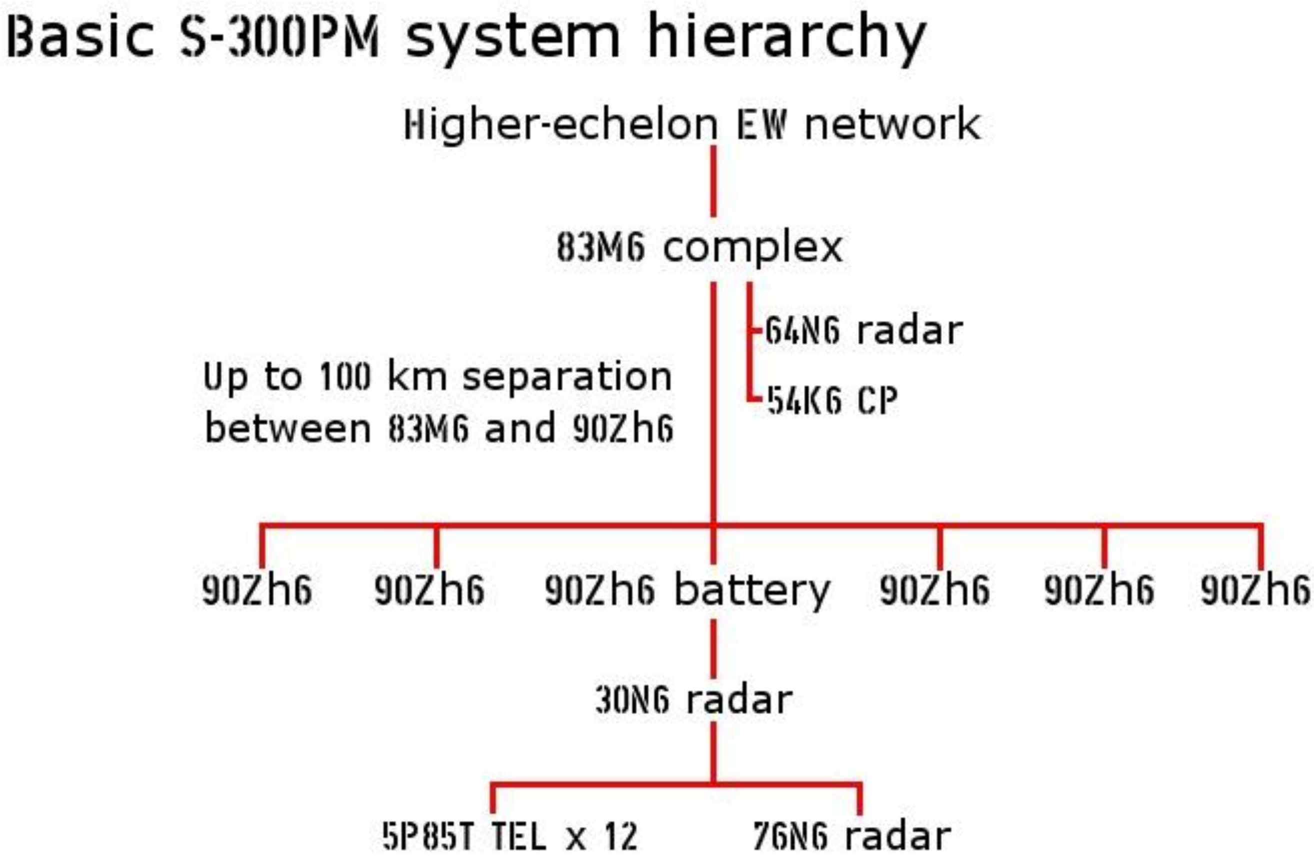
When placed within 20 kilometers of the battle management complex, the engagement radars may communicate directly with the battle management complex using radio command signals to pass target track data. At distances of over 20 kilometers, the battery employs 25 meter FL-95 series antenna masts to facilitate radio communication over long range. Alternatively, system components may use cable connections to reduce the electronic signature of the complex. The latest systems can employ fiber optic communications systems.

When employing 5P85S/D TELs, they typically site in groups of three. One 5P85S TEL resides between two subordinate 5P85D TELs. The 5P85D TEL cabins position to angle towards the cabin of the 5P85S, with separation at the front of the vehicles being 2 to 3 meters and separation at the rear of the vehicles being 5 to 6 meters. Cable connections connect the 5P85D TELs to the 5P85S TEL's F-3S container. 5P85S TELs can reside up to 100 meters from the engagement radar complex's F2 container and communicate via radio or cable connections.

The engagement sequence for the S-300P is as follows:

- Targets are located and tracked by the battle management radar, autonomously or following track hand-down from a higher-level EW network
- Track data is fed into the battle management complex
- Targets are prioritized according to the potential threat
- The battle management complex assigns target track data to subordinate engagement radars
- Track data is processed by engagement radar complexes to generate initial guidance commands
- Initial missile guidance commands are loaded into the missile guidance systems
- Missiles are launched 3-5 seconds apart, up to 2 missiles per target
- Missile guidance is accomplished
- Targets are re-attacked if necessary

The ability of the S-300P and S-400 variants to employ various types of missiles is an important attribute. The plethora of available weapons allows the SAM complex to select the most appropriate weapon for the designated target. For instance, in a jamming-free environment, the system selects a 5V55K missile, reserving the 5V55R or 48N6 weapons for more difficult targets. The S-300P or S-400 may select different missile types automatically, as evidenced by S-300PT-1 cold-weather operational testing from



December 1983 to January 1984 at the Telemba SAM training range.

In one particular instance, a test evaluated the automatic engagement mode of the system. In this mode, every process from track hand-down to missile spin-up occurs automatically, with the only human input being to press the launch button.

The test called for target engagement to take place at maximum range with a 5V55R missile. The target entered the launch range, but missile launch did not occur. The operators had not realized that the missile economy algorithm was set to active, resulting in the appearance of a failed test.

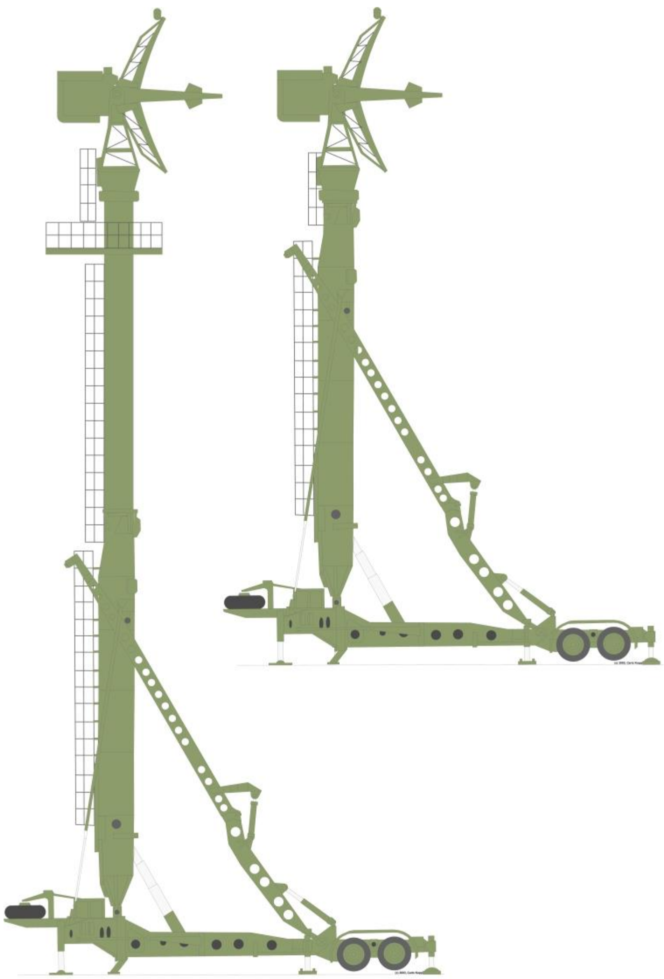
The missile economy algorithm, when active, will allow the system to select a 5V55K weapon if the engagement environment is free from jamming or interference. During the test, the system had designated the target for intercept by a 5V55K missile, which has a smaller engagement range than the 5V55R. As the target had not yet passed within the range of the 5V55K, track data processing had not yet occurred. After realizing the error, testing progressed and validated the system's automatic performance.

Defending Moscow

While not conceived as a direct replacement for the S-25 SAM system used to defend Moscow, the S-300P would play a significant part in modernizing the then-Soviet capital's air defenses. The Ministry of Defense began developing concepts for an improved air defense network for the capital in 1978.

The advent of low-altitude and low-RCS targets such as cruise missiles represented targets that the S-25 was not capable of effectively countering. Development of plans to employ S-300P complexes as S-25 replacements began in 1980. S-25 sites were located in two rings around Moscow, and sites along the outer ring were the first to receive the new SAM system. Work on the new Moscow air defense network ended in 1994.

Deploying the S-300P at S-25 sites around Moscow required the addition of a 19-meter insert to the existing 40V6 series mast assemblies, resulting in the 40V6MD variant. Additional height was necessary to ensure a clear field of view for the battery-level radar systems. Without a similar solution, the 5N64 and 64N6 radar systems would suffer the same issues as the engagement radars and low altitude detection radars.



76N6 deployed atop 40V6M (upper right) and 40V6MD (lower left) mast assemblies (Carlo Kopp)

With individual SAM complexes tied in to separate zones around Moscow, the PVO decided to emplace the battle management complexes at fixed locations, with large elevating platforms constructed to raise the battle management radars above the forests and terrain. Individual batteries would retain the 40V6 series mast assemblies to enable them to redeploy to a degree within their assigned zones, albeit eschewing the 5-minute redeployment time of the unaided system.

This arrangement is unique to the Moscow area and is possible because the SAM batteries are in place to defend the capital. As such, the battle management complexes and SAM batteries do not expect to redeploy to a great degree.

Russian 64N6 radar system mounted atop an elevated platform near Moscow (Google Earth)

Deployment Strategy

The S-300P series, along with the follow-on S-400, represents a family of strategic SAM systems. Strategic SAM systems defend key facilities, infrastructure, population centers, and national borders. While these systems may enjoy varying degrees of mobility allowing them to relocate during hostilities, they do not act as mobile batteries protecting maneuver formations.

S-300P series and S-400 batteries follow standard strategic SAM deployment doctrine regardless of the user. Each operator deploys individual batteries to protect important locations, typically including capitals and potential conflict zones.

Operational battery composition often varies between systems. S-300PT systems

typically consist of the 5N63 engagement radar and twelve 5P851 TELs. Mobile S-300PS and S-300PM systems employ batteries typically consisting of between four and twelve TELs. S-300PM batteries typically deploy at full strength, with twelve TELs operational, while S-400 batteries deploy with eight TELs. This practice allows for the deployment of additional equipment held in reserve should it become necessary.

In actuality, the only advantage to a full-strength battery is the increased time required before accomplishing missile reloads. With the system only capable of supporting twelve missiles in flight, peacetime requirements will not necessitate a full-strength battery deployment. Four deployed TELs are sufficient to support the maximum number of engagements while retaining four additional missiles for re-attack. Furthermore, deploying a battery at less than full strength reduces the maintenance requirements and operating costs necessary to keep the battery in service.

Deployment of both higher-echelon and battery-subordinate radar systems differs between users and is typically dependent upon the systems acquired. FSU users operating the 5K63 or 83M6 battle management complexes rely on 5N64 or 64N6 series radars to provide target track assignment to subordinate batteries. Initial export clients relied on 36D6 series radars rather than the dedicated battle management radars employed by the FSU.

The employment of different battle management radars resulted in different deployment strategies for individual users. Users relying on the more advanced 5N64 and 64N6 series radars sited the battle management complexes separately from their subordinate batteries. In the case of the Moscow region, 83M6 complexes are sited at a distance of two to three kilometers behind subordinate S-300PM batteries. In contrast, users relying on less-advanced radars such as the 36D6 commonly co-located the battle management complex with the firing battery.

S-300PM battery and 83M6 complex occupying a former S-25 site northwest of Moscow; separation is 2.75 kilometers (Google Earth)

Battery-subordinate radar systems deploy in accordance with the requirements of the location where they reside. In Moscow area S-300PM and S-400 batteries, 40V6 series mast assemblies mount both the engagement radar and the 76N6 or 96L6 acquisition radar to provide clearance from local vegetation.

Basing

Prior to the appearance of the S-300P series, Soviet strategic SAM systems typically employed dedicated fixed sites. These fixed sites featured dedicated revetments and buildings to support a complete battery, and typically employed a standardized layout making identification via overhead imagery relatively uncomplicated.

The S-300P and S-400 series rely on both legacy and new site designs. Reliance on pre-existing legacy sites allows a user to forgo the expense of constructing a new site. Alternatively, some users construct new sites for their batteries. Reasons for this practice include a lack of a pre-existing legacy site for modification, a legacy site unsuitable for modification, or a desire to place the system in a new location to maximize its capabilities. System mobility also permits deployment on an unprepared site, requiring only geodesic tie-in

with the battle management complex to begin operation.

Legacy site basing is a common occurrence, particularly among former Soviet states possessing a significant number of such facilities. S-300P series batteries currently deploy at sites formerly constructed for S-25, S-75, S-125, and S-200 batteries.

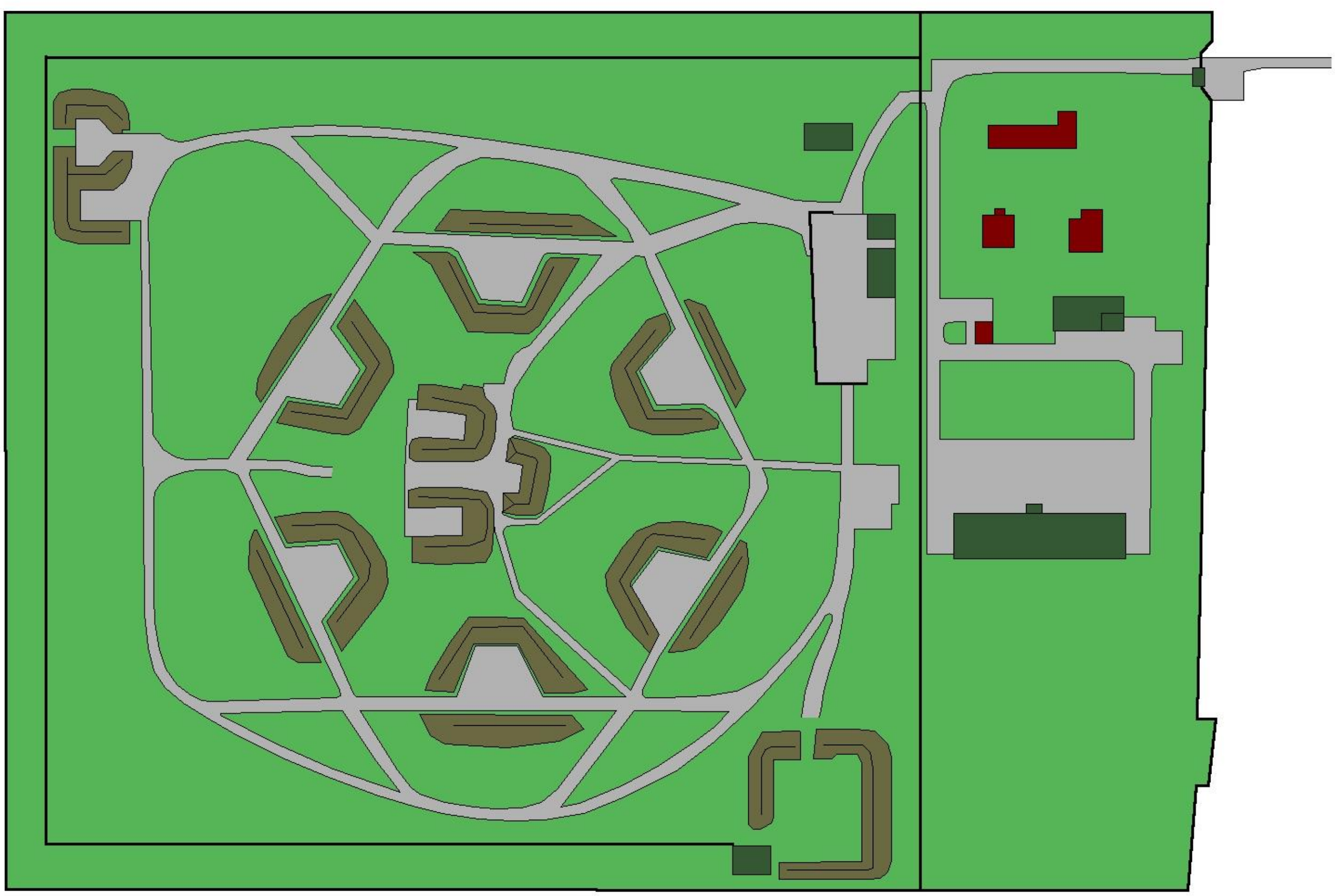
Legacy sites intended to host S-300P or S-400 series batteries typically require various modifications to accommodate the new equipment. These modifications include the laying of concrete pads for TELs and 40V6 series mast assemblies and the construction of a raised berm to site the engagement radar.

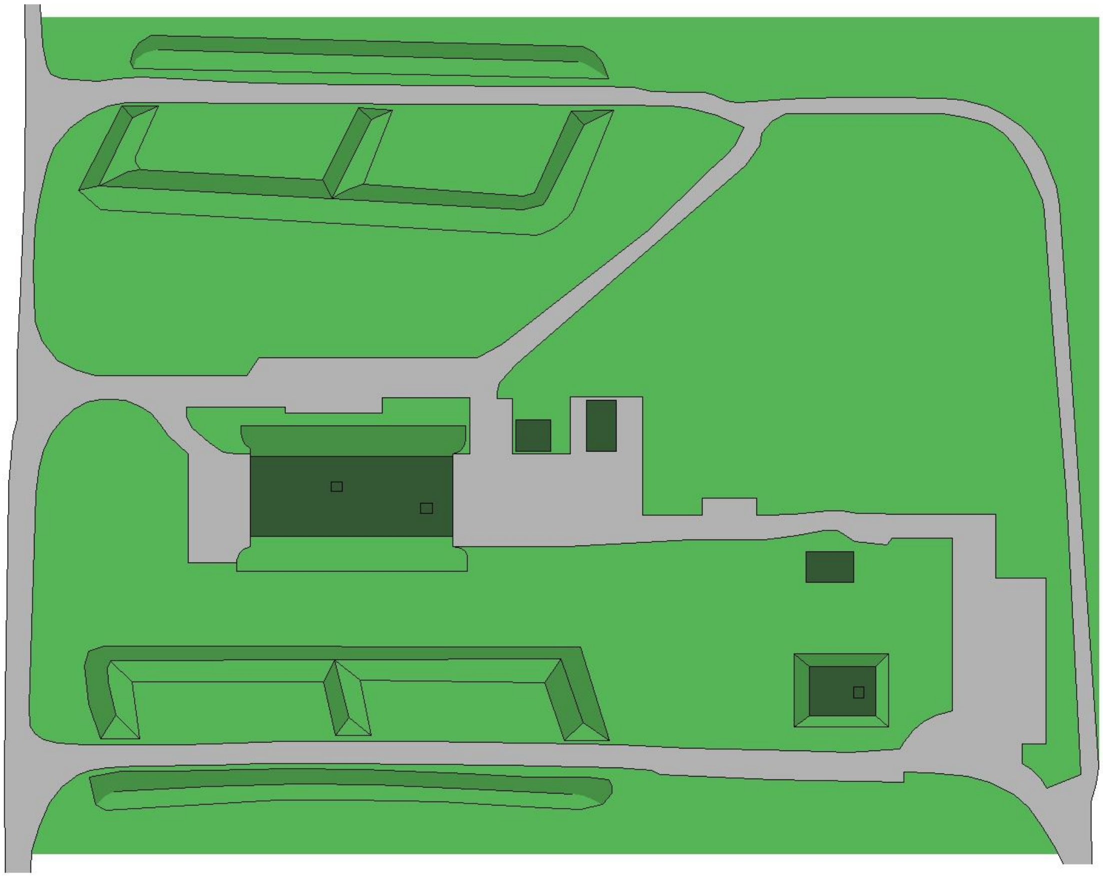
Other export clients have demonstrated much less intrusive site modification efforts when preparing legacy sites to host S-300P series components. Some clients, such as Greece, forego the construction of new sites altogether and take advantage of the system's deployability to site it where needs require.

The deployment of S-300PM batteries on former S-25 complexes around Moscow ultimately necessitated the creation of new sites. S-25 complexes featured expansive launch areas for the Lavochkin V-300 series missiles. These launch areas consisted of multiple pads mounting a single missile each, with bunkers housing support equipment.

In comparison to other legacy sites such as those housing the S-75 or S-200, S-25 sites did not lend themselves to the basing of S-300P series batteries. However, the in-place architecture of the S-25 network provided a starting point for the modification of Moscow's air defenses, provided alteration to the sites took place.

Alterations to the S-25 sites consisted of clearing areas around chosen bunkers to site the S-300PM batteries and constructing the necessary infrastructure to house the new





systems. Revetments designed to house the TELs featured a “slanted-E” layout. Each half of the “E” housed three TELs. A berm placed adjacent to the “E” provided the TEL trios with 360-degree protection. This protection extended to both internal and external threats: internal threats consisted of fires and the potential of an accident resulting in the detonation of a missile. The “slanted-E” revetment shape is in widespread use around Russia and former Soviet states at S-300P series sites, indicating that it also serves as a “new-build” site design.

FOREIGN OPERATORS

Foreign Service

The S-300P series has been widely exported and remains a highly sought after commodity in the international arms market. Initial foreign operators consisted of former Soviet republics retaining control over air defense assets in their new territory. Eventually, the S-300PMU and later variants entered the formal export market, beginning with Warsaw Pact members. As newer S-300PM systems entered Russian service, the PVO withdrew many older S-300PT and S-300PS batteries from service, placing them in garrison or storage facilities. After refurbishment, many of these systems also found their way to export users.

FSU and Warsaw Pact Operators

Belarus and the Ukraine each retained S-300PT and S-300PS batteries following the breakup of the Soviet Union, while Kazakhstan retained S-300PS batteries. Each nation also gained control of numerous battle management complexes. Belarus and Kazakhstan also received refurbished Russian S-300PS batteries to boost their air defense networks.

S-300PMU exports began during the end of the Cold War. The Soviet Union exported two batteries to Bulgaria, one battery to East Germany, and four batteries to Czechoslovakia. All S-300PMU batteries exported by the USSR featured battle management complexes equipped with the ST-68U radar rather than the 5D6E or 64N6E.

Given the limited number of systems available to former Warsaw Pact operators, their batteries primarily deploy in a capital area defense posture. FSU operators, with larger inventories, adopted more advanced deployment strategies.

Belarus contracted with Russia for four refurbished S-300PS batteries and two 5N83S battle management complexes in 2005. The batteries are in service near Brest and Grodno where they supplement S-300PT and S-300PS batteries deployed elsewhere in the nation. Brest and Grodno each received two batteries and a single 5N83S complex. Belarus also desires to import the S-400 when export clearance of the system is available. Current reporting suggests that the S-400 will be available to Belarus and Kazakhstan in 2015.

Belarusian deployment concentrates on capital area air defense of Minsk, and defense of the western border with Poland. The western deployment, claimed to be a response to Polish acquisition of F-16s, may indicate a tasking stemming not from purely Belarusian interests but rather from those of the joint CIS air defense network of which Belarus is an active participant.

S-300PS deployed near Brest in Belarus (Google Earth)

Belarusian batteries deploy using one of two site configurations. Capital area batteries deployed around Minsk employ Russian-style slanted-E revetments. Batteries deployed along the western border reside at converted S-75 or S-125 complexes.

Compared to Belarus, Ukrainian deployment possesses greater depth of coverage due to the presence of a greater number of systems. In total, the Ukraine operates more than twice as many identified active batteries as Belarus. As such, Ukrainian batteries deploy to defend multiple locations.

Ukrainian batteries defend Dnepropetrovsk, Kiev, Kharkov, Lviv, and Odessa. Additional batteries defend various installations along the Dnieper River, and on the Crimean Peninsula.

Ukrainian S-300PT batteries are deployed predominantly at older-style S-300P sites, containing six revetments for two TELs apiece, or four revetments for three TELs apiece and a position for a mast-mounted 5N63 in the center. S-300PS batteries are deployed predominantly at newer-style sites, featuring four TEL revetments and a significant raised berm in the center for the mobile 5N63S engagement radar. It is likely that S-300PT sites were built over old S-75 locations, explaining the similar launcher revetment placement. An S-300PS battery northwest of Kiev is deployed at what would typically be a six-revetment S-300PT site, likely indicating that the S-300PS replaced an S-300PT battery at this location. S-300PT components visible stored at the site reinforce this assertion.

Ukrainian S-300PS battery near Kiev deployed on a site featuring S-300PT style revetments (Google Earth)

Kazakhstan received eight S-300PS, batteries in 2000. Initially reported as S-300PMU batteries, in reality Kazakhstan's systems were not the export S-300PMU, but refurbished Russian S-300PS systems. Kazakhstan is on record as having an interest in the S-400, and expects to take delivery of ten S-300PMU-2 batteries in the near future.

Kazakhstan primarily employs the S-300PS to defend the capital of Astana and the city of Almaty in the south. Newer S-300PS batteries delivered from refurbished Russian stocks deploy to protect other important areas, with the first noted battery deploying west of Shymkent.

Kazakh S-300PS battery deployed near Shymkent (Google Earth)

The DDR, home to large numbers of both East German and Soviet military units, pursued the S-300PMU in the early 1980s. Site preparation began in 1984 near Retschow in the 43rd FRBr, and system operators trained in the USSR between August and December of 1988. The first S-300PMU battery entered service in 1989, but remained active for a very short period before reunification. Following reunification, the S-300PMU battery returned to the USSR.

The S-300PMU was delivered to Czechoslovakia in 1990, becoming part of the 71st PLRB. The S-300PMU was intended to replace most of the extant S-75M Volkhov units inside of Czechoslovakia, but the cessation of the Cold War brought these plans to a halt. In the end, only a single S-300PMU battery was activated, replacing an S-75M battery at a site near Prague.

Former Czech S-300PMU complex west of Prague (Google Earth)

Following the breakup of Czechoslovakia in 1993, the Czech S-300PMU battery was transferred to Slovakia, where it became part of the Slovakian 36th PLRB. Currently based near Nitra to the east of Bratislava, the S-300PMU battery represents Slovakia's most capable air defense system.

Slovakian S-300PMU battery deployed on a reprofiled S-125 complex (Google Earth)

Slovakian graphics displayed with system components during military open houses suggest an engagement range of 75 rather than 90 kilometers. This suggests that the USSR did not export the increased-range 5V55RUD missile to some clients.

Bulgaria imported the S-300PMU in 1989, taking delivery of two batteries during a major military improvement program. At least one battery remains operational near Sofia. A second prepared S-300P series site near Sofia suggests the ability to deploy a second battery, or redeploy the operational unit.

Bulgarian S-300PMU battery deployed near Sofia; note the ST-68U at upper right (Google Earth)

Inactive Bulgarian S-300P series site (Google Earth)

FSU and former Warsaw Pact operators continue the Soviet-era practice of basing the S-300P series batteries on existing legacy SAM complexes. In some cases substantial site modification is undertaken to facilitate S-300P series operation, but is not a requirement

given the mobility and deployability of the system.

S-300PS battery occupying part of a former S-200 site near Sevastopol in the Ukraine (Google Earth)

China

China is the largest importer of the S-300P family. Preliminary orders in 1991 were for eight S-300PMU batteries delivered in 1993 at a cost of $220 million. In 1994, China placed a $400 million order for eight S-300PMU-1 batteries, with an identical order placed in 2001. China also became the launch customer for the S-300PMU-2 in 2004 when it ordered sixteen batteries at a cost of $980 million.

China received 5P85SU/DU TELs for the S-300PMU, but switched to towed TELs for follow-on orders. Almaz-Antey delivered the S-300PMU-1 batteries with the 5P85TE, while the S-300PMU-2 batteries employed the 5P85TE2 TEL derived from the S-400's 5P85TM. S-300PMU-2 batteries also came equipped with the 96L6E radar; prior systems employ 36D6 and 76N6E radars as battery-level acquisition systems.

The S-300PMU provided China with its first modern strategic SAM system. Initial deployments around Beijing and Nanchang served two purposes. The northern batteries provided capital area air defense, while the southern batteries resided in a location suitable for rapid redeployment to the Taiwan Strait.

S-300PMU complex near Nanchang; note protective garages for TELs and engagement radar (Google Earth)

Initial S-300PMU-1 deliveries boosted defense around Beijing and Shanghai, with S-300PMU-2 deliveries providing defense to key installations. The range of the SAM systems, coupled with site selection for newly deployed batteries, enabled China to erect a nearly contiguous air defense barrier along its eastern border.

Chinese S-300PMU-2 battery deployed near Tieshan; note separate berm for 96L6E EW radar (Google Earth)

Chinese S-300P batteries deploy at a reduced capacity, with a full strength battery rarely seen operational. This practice reduces normal wear and tear on system components, thereby reducing maintenance and operating costs for individual batteries.

Unusually active S-300PMU-1 battery deployed near Beijing with eight deployed TELs (Google Earth)

China adopted an extensive modification procedure when adapting legacy HQ-2 sites to house new S-300P series batteries. Replacing an HQ-2 battery with a new HQ-12 system involved relatively minor alterations to the radar position and existing launcher revetments. In contrast, the razing of former HQ-2 positions selected to house S-300P series batteries preceded the construction of sites bearing little similarity to their previous layouts.

One noteworthy feature at many S-300P series sites in China is the adoption of sliding-roof garages for TELs and engagement radars. Not only does this offer a degree of environmental protection, but also masks the actual system variant deployed at a given site.

While S-300PMU-2 batteries deploy on a large basis, with fourteen operational batteries sited in imagery out of sixteen delivered, a discrepancy exists with deployed S-300PMU and S-300PMU-1 batteries. Seven unoccupied sites likely represent S-300PMU-1 positions, bringing operational deployment capacity to the same level seen with the S-300PMU-2. The greatly reduced number of S-300PMU systems deployed, with only three operational batteries noted out of eight delivered, is explained by the possible consumption of system components by the HQ-9 development program. Initial photographs of HQ-9 trials components suggested significant design influence from the S-300P series.

Greece

Greek S-300PMU-1 components stem from the system's attempted acquisition by Cyprus. In 1995, the government of Cyprus began to examine the possibility of procuring an air defense system. Turkish military aircraft had frequently been seen over the skies of Cyprus with no regard to territorial sovereignty, and the December 1995 announcement of the sale of the ATACMs missile system to the Turkish military represented a new threat system capable of hitting targets in Cyprus from the safety of Turkey.

Cypriot Foreign Minister Alecos Michaelides announced the purchase of the Russian S-300PMU-1 strategic SAM system on 5 January 1997. Turkish reaction to the Cypriot SAM purchase was illogically stern. On the 11 January 1997 the Washington Times reported that Turkey threatened a pre-emptive strike against Cyprus in order to block the deployment of the missiles. One oft-cited reason for Turkish annoyance at the deal was the supposed capability of the system to perform in a surface-to-surface role.

Following Turkish protests, Greece took delivery in 1998 of the two S-300PMU-1 batteries ordered by Cyprus. The batteries employ the 5P85TE TEL, and are supported by a 64N6E battle management radar.

Greek S-300PMU-1 batteries garrison at Timpaki and Nikos Kazantzakis airfields, with operational deployment noted at the latter location. No apparent effort exists to construct dedicated sites for the S-300PMU-1, with

components instead field deploying on existing infrastructure.

Greek 30N6E1 and 5P85TE TELs sited at Nikos Kazantzakis airport on Crete (Google Earth)

While no S-300PMU-1 SAM systems were ever deployed to Cyprus, Russian technicians did travel to the island nation and construct three sites, two for the missile systems and one for the 64N6E EW and battle management radar. One missile site, along with the 64N6E site, was constructed atop Mount Olympus. The second missile site was constructed in the western part of the island near Drousha.

Unoccupied S-300PMU-1 complex sited on Mt. Olympus, Cyprus (Google Earth)

Vietnam

Vietnam ordered two S-300PMU-1 batteries in 2003 at a cost of $200 million, taking delivery in 2005. Vietnam was the launch customer for the 96L6E, purchasing the system for its S-300PMU-1 batteries. Vietnam also purchased the 5P85SE TEL, the only S-300PMU-1 customer to do so.

Vietnamese S-300PMU-1 batteries deploy to defend Hanoi and Ho Chi Minh City, operating from newly-constructed sites featuring a unique layout. The southern location exists on the grounds of a former S-75 complex, razed and reconfigured to host the new system.

S-300PMU-1 components deployed near Ho Chi Minh City (Google Earth)

Algeria

In 2006, Algeria ordered eight S-300PMU-2 batteries as part of an arms package, with deliveries beginning in 2010. To date, no systems appear operationally deployed, with system components only sighted in imagery at a SAM training complex east of Algiers beginning in August 2011.

Algerian S-300PMU-2 batteries appear destined to deploy at heavily modified S-125 positions. Two such locations near Algiers underwent conversion between September 2007 and April 2011, implying an initial capital area air defense role for the systems. Further deployment locations remain unlocated, but the apparent desire to convert extant S-125

positions indicates that future deployment sites will likely be discernable in overhead imagery due to site reconfiguration efforts.

Algerian S-300PMU-2 complex converted from an extant S-125 position (Google Earth)

Armenia

Armenia received at least three ex-Russian S-300PT batteries by 2008. By 2010, Armenia received S-300PS components, with two 5P85S TELs and a mobile 5N63S engagement radar appearing on an Armenian news broadcast.

Armenian S-300PT battery deployed near Yerevan; note the separated 5N66 acquisition radar position (Google Earth)

Armenian S-300PT batteries serve as capital area air defense assets, deploying around the capital of Yerevan where they displaced aging S-125 batteries. A 5N83 battle management complex with its associated 5N64 radar system supports the S-300PT batteries.

Armenia's S-300PS batteries deploy near the Nagorno-Karabakh border in Syunik province. The two sites, near Goris in the north and Kaghnut in the south, both reside within seven kilometers of the border. Only the Kaghnut battery resides on a prepared site, the complex specially designed to accommodate the local terrain. Both batteries employ a 5N63S mobile engagement radar and mast-mounted 5N66M low-altitude EW radar. As imaged in 2011, the Goris battery currently operates four 5P85S/D TELs, with the Kaghnut battery operating eight.

Armenian S-300PS complex under construction in 2009 (Google Earth)

Deployment of the mobile S-300PS batteries in Syunik province places the entire Nagorno-Karabakh region under the protection of Armenia's air defense network. Furthermore, the S-300PS enjoys mobility that the S-300PT does not, enabling rapid relocation when required. As such, either S-300PS complex represents a possible occupant for the S-300P complex constructed near Stepanakert in Nagorno-Karabakh, supplementing or replacing extant 2K11 or S-

125 batteries in the region. The location of the S-300PS batteries permits target track assignment from either the Yerevan-based 64N6 battle management radar or a Nagorno-Karabakh based 36D6 EW radar.

Azerbaijan

Azerbaijan reportedly ordered two S-300PMU-2 batteries in 2010, a report initially denied by Rosoboronexport. On 26 June 2011, Azerbaijan displayed two S-300PMU-2 TELs during a military parade in the capital of Baku, indicating that the previously denied sale did in fact exist.

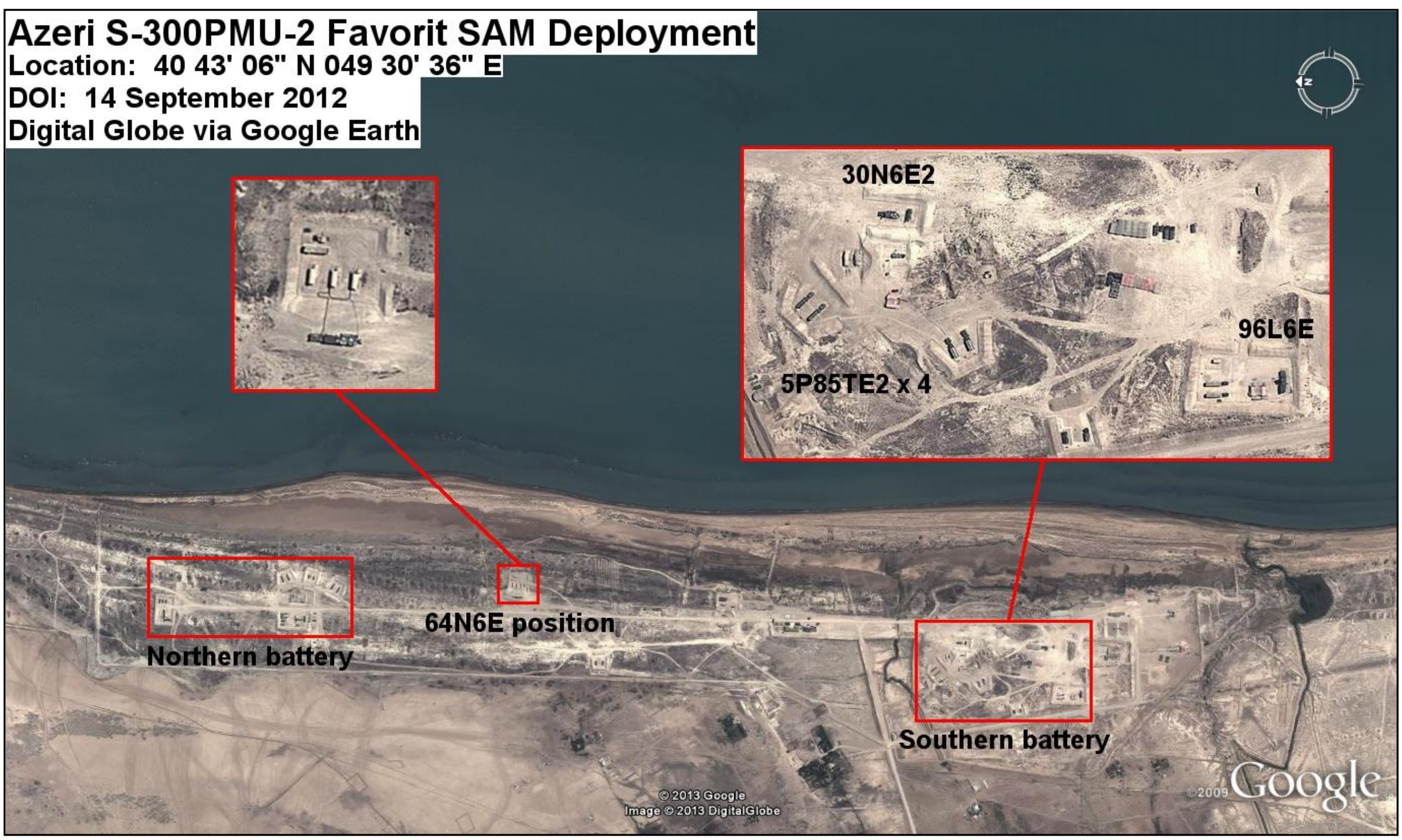
Azerbaijan deploys two Favorit batteries and a single battle management complex on the coastline northwest of Sumgait. Each battery possesses a 30N6E2 engagement radar and a 96L6E acquisition radar, with four 5P85TE2 TELs. The northern battery also possesses two 40V6 series mast assemblies adjacent to the two radar systems. The central position employs the 64N6E2 battle management radar. The southern site is emplaced on a reprofiled former S-75 position, with the northern site emplaced on a newly built semi-hardened position. The site buildup suggests a permanent deployment location.

Azeri S-300PMU-2 batteries appear sited to perform capital area air defense of Baku, although the system mobility permits relocation in a short period of time. System capability effectively negates any aerial threat posed by the Armenian military. Furthermore, the ATBM capability of the system removes Soviet-era SCUD missiles from the threat picture.

Future Operators

In 2010, Libya ordered the S-300PMU-2 as part of an arms package. UN operations in Libya during the first quarter of 2011 precluded the delivery of any new weapon systems to Qaddafi's regime, and the end result of Qaddafi's overthrow left a nation in no condition to resume negotiating for multi-million dollar SAM systems.

Iran, India, and Syria often appear in various sources as S-300P series users or customers. India considered the system in the



late 1990s, but did not place an order.

Syria has been attempting to procure the system for some time, but has not yet taken delivery. Reportedly, Syria and Russia agreed on a contract for four S-300PMU-2 batteries, but Russia suspended delivery due to the ongoing situation.

Iran remains a potential client, contracting for the S-300PMU-2 in 2007. Russia cancelled the sale in late 2010 following international pressure, despite the fact that strategic SAM systems remain acceptable for sale under the United Nations, with Iran threatening legal action. This contract followed unsubstantiated reporting claiming that Belarus transferred various S-300PT components to Iran in 2008. Were such components imported, their age and comparatively limited capability likely led to their use as a technology base for developing the rumored Bavar-373 strategic SAM system. Bavar-373, only displayed in very crude mockup form during military parades, is claimed by Iran to be an S-300 equivalent. The capability of such a system is extremely suspect given Iran's continued desire to procure the S-300PMU-2.

The only known former operator of an S-300P series system is Croatia. Croatia imported S-300P components from the Ukraine in 1994, displaying 5V55 series missile canisters during a 1995 parade in the capital of Zagreb. The system never entered service, with the components later transferred to Israel and the United States.

Identified S-300P/400 sites in overhead imagery

Country	Type	Active	Inactive	BMEW
Algeria	S-300PMU-2	0	2	0
Armenia	S-300PT	3	0	1
	S-300PS	2		
Azerbaijan	S-300PMU-2	2	0	1
Belarus	S-300PT	5	1	4
	S-300PS	7		
Bulgaria	S-300PMU	1	0	0
China	S-300PMU	3	7	7
	S-300PMU-1	7		
	S-300PMU-2	14		
Cyprus	S-300PMU-1	0	2	1
Czech Republic	S-300PMU	0	1	0
Estonia	Not in service	0	2	0
Greece	S-300PMU-1	1	0	1
Kazakh.	S-300PS	4	1	2
Latvia	Not in service	0	7	0
Lithuania	Not in service	0	3	0
Moldova	Not in service	0	1	0
Nagorno-Karabakh	Not in service	0	1	0
Russia	S-300PT	6	112	38
	S-300PS	38		
	S-300PM	22		
	S-400	6		
Slovakia	S-300PMU	1	0	0
Ukraine	S-300PT	15	26	10
	S-300PS	14		
USA	S-300PMU	1	0	0
Vietnam	S-300PMU-1	1	1	0
Totals		153	167	65

SYSTEM EXPLOITATION

Exploitation

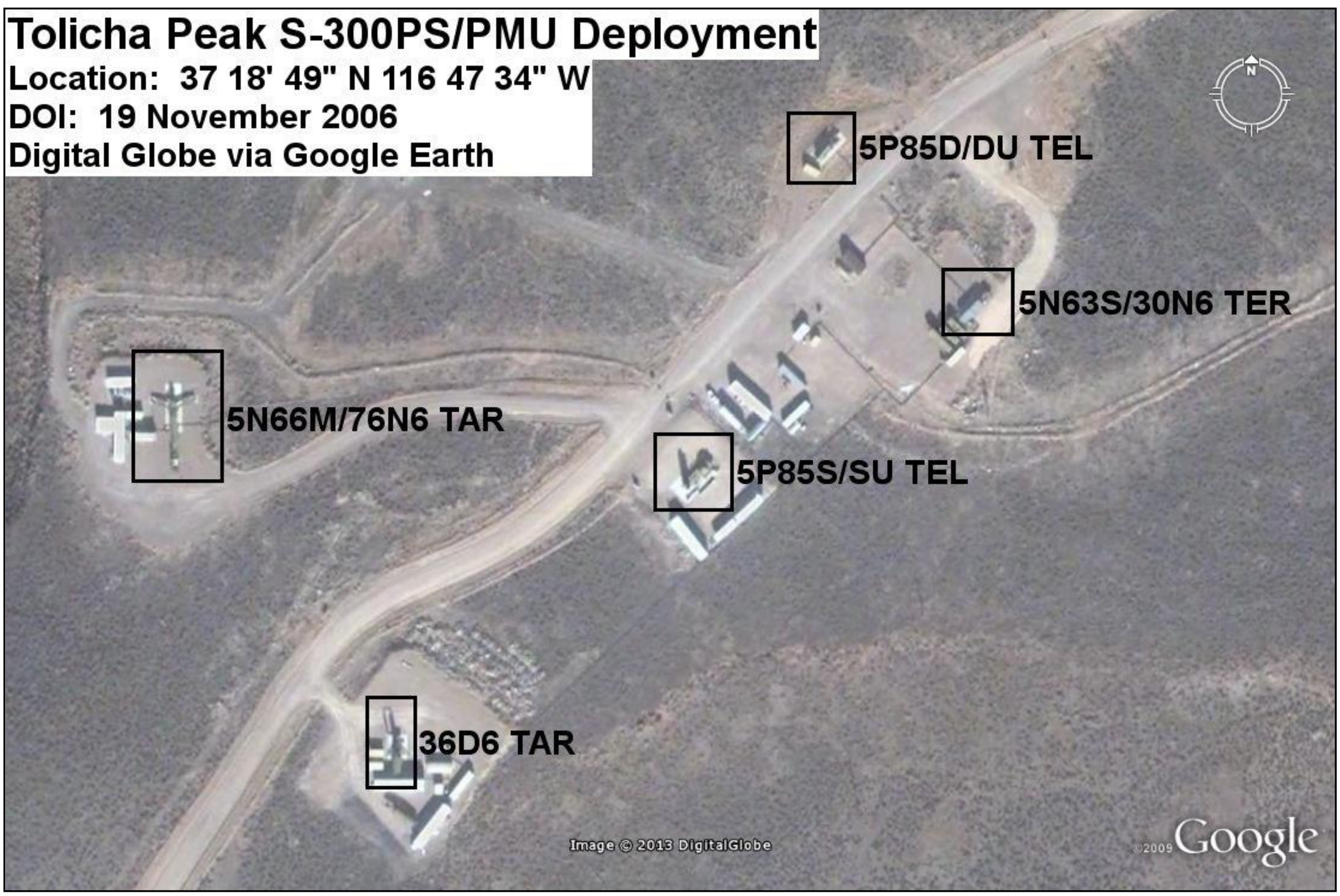
Given the high threat posed by S-300P series SAM systems, various nations have performed system exploitation on its components. This practice serves to derive the performance and characteristics of a threat system, to allow for the development of countertactics and electronic warfare techniques.

The United States serves as one of the primary exploiters of S-300P series components. Open-source reporting indicates that Belarus, Croatia, Russia, and the Ukraine have transferred or sold system components to the United States.

System exploitation is typically a sensitive topic and not publicly acknowledged to a great degree. Open-source imagery analysis, however, depicts various S-300P series system and related components at locations in the United States.

The most prominent US location featuring S-300P series components is Tolicha Peak Electronic Combat Range (ECR). Tolicha Peak ECR is home to S-300P series battery components. Shadowing allows for the clear identification of both a 5P85S and 5P85D TEL. Also present are three radar systems: a 5N63S radar, a 36D6 EW radar, and a probable 5N66M engagement radar mounted on a 40V6 series mast assembly. Depending on the acquisition source, Tolicha Peak ECR's S-300P series may include S-300PS or S-300PMU components, or a mix of both systems.

The presence of S-300P series components at Tolicha Peak ECR allows the system to serve two objectives: system exploitation and crew training. Tolicha Peak ECR supports Nellis AFB range operations by providing threat emitter systems for realistic training operations. Alternatively, the isolated location allows for examination and exploitation of the components, possibly including missile



launches.

S-300P series components also exist at a compound on the Eglin AFB range in Florida. This complex features various examples of foreign weapon systems and radar components. S-300P series components visible in overhead imagery are a 5P851 TEL and 5P85S series TEL.

5P85S (upper) and 5P851 (lower) TELs imaged at Eglin AFB (Google Earth)

Two other locations contain associated 36D6 EW radars for exploitation or training operations. A 36D6 is present on the NAS Fallon range complex in Nevada, with a second example present on the range complex at RAF Spadaedam in the UK. RAF Spadaedam often supports British and NATO crew training, providing a realistic threat emitter environment comparable to that experienced on the Nellis AFB range complex in the United States.

NAS Fallon 36D6 EW radar (Google Earth)

While NAS Fallon and RAF Spadaedam lack additional S-300P battery components, exploitation of related systems such as the 36D6 can provide valuable insight into the EW capabilities of an S-300P series battery. Furthermore, the presence of 36D6 EW radars possibly indicates that other command and control systems such as the export-standard 83M6E battle management complex are present and undergoing evaluation.

RAF Spadaedam 36D6 EW radar (Google Earth)

Apart from the United States and the UK, Israel has exploited S-300P series components. Israel reportedly received a 5N63S from Croatia in 1998, and between May and June of 2008 exercised against Greek S-300PMU-1 batteries to gain experience against and evaluate the performance of the newer 30N6E1 engagement radar. Israel often claims the ability to defeat the S-300P series, but such claims are questionable given the continued opposition to sales of the system to Iran and Syria.

Decoy and Target Sites

Various aerial target and gunnery ranges in the US and UK feature mock S-300P series site layouts. Mock site layouts serve multiple purposes to add realism to aircrew and support personnel training.

By placing a notional threat system near a target facility, aircrew can plan and execute mission profiles designed to counter or defeat such a threat. In addition, mock site layouts serve to train the pilots of combat aircraft and ISR assets, as well as their intelligence support components, in the visual identification of threat systems.

Mock site layouts vary widely in complexity, with some sites representing notional deployment locations, and some sites featuring mockups of system components.

Mock 5N63S engagement radar at RAF Spadaedam (Google Earth)

Mock S-300P-series SAM battery deployed at Centennial Range, New Mexico. Various vehicles represent battery components, with vertical tubes representing TELs erected for launch (Google Earth)

Mock S-300P-series SAM battery deployed at Razorback Range, Arkansas. TELs are simulated using vertical tubes similar to those at Centennial Range, but no support vehicles are depicted (Google Earth)

Two "slanted-E" S-300P series SAM sites on target ranges at White Sands Missile Range, New Mexico (Google Earth)

Two mock 5P85S TELs at RAF Spadaedam (Google Earth)

WESTERN DESIGNATORS

Codenames

The Western military nomenclature for the S-300P/S-400 has often been a source of confusion. In the case of SAM systems, multiple codenames refer to either a complete system or an individual component. The US DoD assigns an SA-series numerical designator to a SAM system, while NATO employs codenames derived by multinational organizations such as the ASIC to indicate a given radar or missile type. Correctly formatted designators will appear in all capitals.

The US DoD initially assigned the SA-10 designator to the S-300PT. This became the SA-10A when the S-300PS appeared as the SA-10B. 5V55 series missiles received the codename GRUMBLE. The S-300PM initially received the designation SA-10C. When the new 48N6 missile and 30N6 engagement radar were identified, the system was re-designated SA-20 to account for the new components and increased capability. The 48N6 series missiles received the codename GARGOYLE. Most recently, the S-400 received the designation SA-21, with the 48N6DM receiving the codename GROWLER.

The US DoD never assigned the SA-10D, SA-10E, and SA-10F designations. These designators remain a product of the Western media, particularly found in places where the SA-20 designator is not used and the SA-10C designator remains. At this point, there is no reason for this oversight to occur.

Further confusion arises from the improper use of radar designators in the media. Various publications confuse the SA-10's FLAP LID with the SA-20's TOMB STONE, referring to all engagement radars for the S-300P series as FLAP LID variants. Likewise, some sources refer to the 64N6 battle management radar as TOMB STONE rather than the correct BIG BIRD, although this at least demonstrates knowledge of the TOMB STONE designator. In addition, the designator CHEESE BOARD is often used for the 96L6 radar series, although it remains unconfirmed.

It is important to note the separation between system and missile codenames. The Western press often combines these codenames, referring to a system as "SA-2 GUIDELINE" or "SA-5 GAMMON". In reality, SA-2 refers to the SAM system while GUIDELINE refers to the missile itself. Because of the system compatibility with multiple missiles, SA-20A GRUMBLE is a possible combination. In this case, an S-300PM or S-300PMU-1 battery is employing earlier 5V55 series missiles, highlighting the difference between the designators for the SAM system and the missile itself.

Western codenames for S-300P/400 systems

Designator	System
SA-10A	S-300PT
SA-10B	S-300PS/PMU
SA-10C	S-300PM
SA-20A	S-300PM/PMU-1
SA-20B	S-300PMU-2
SA-21	S-400

Western codenames for S-300P/400 missiles

Designator	Missile
GRUMBLE mod 0	5V55K/KD
GRUMBLE mod 1	5V55R/RD
GARGOYLE mod 0	48N6/E
GARGOYLE mod 1	48N6D/E2
GROWLER	48N6DM/E3
None Assigned	9M96/E/D/E2
None Assigned	40N6

Western codenames for S-300P/400 radars

Designator	Radar
BIG BIRD A	5N64
BIG BIRD B	5N64S
BIG BIRD C	5D6E
BIG BIRD D	64N6/E/E2
BIG BIRD E	91N6
CLAM SHELL	5N66/5N66M
CLAM SHELL	76N6
FLAP LID A	5N63
FLAP LID B	5N63S/30N6E
TOMB STONE	30N6/E1/E2
GRAVE STONE	92N6
TIN SHIELD	36D6
TIN SHIELD	19Zh6
TIN SHIELD	ST-68U
CHEESE BOARD	96L6/96L6E

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Site locations sourced from the Worldwide SAM Site Overview KML file available at *IMINT & Analysis*.

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Above: S-300PM battery on the move; below: 5P85S “master” TEL (Almaz-Antey)